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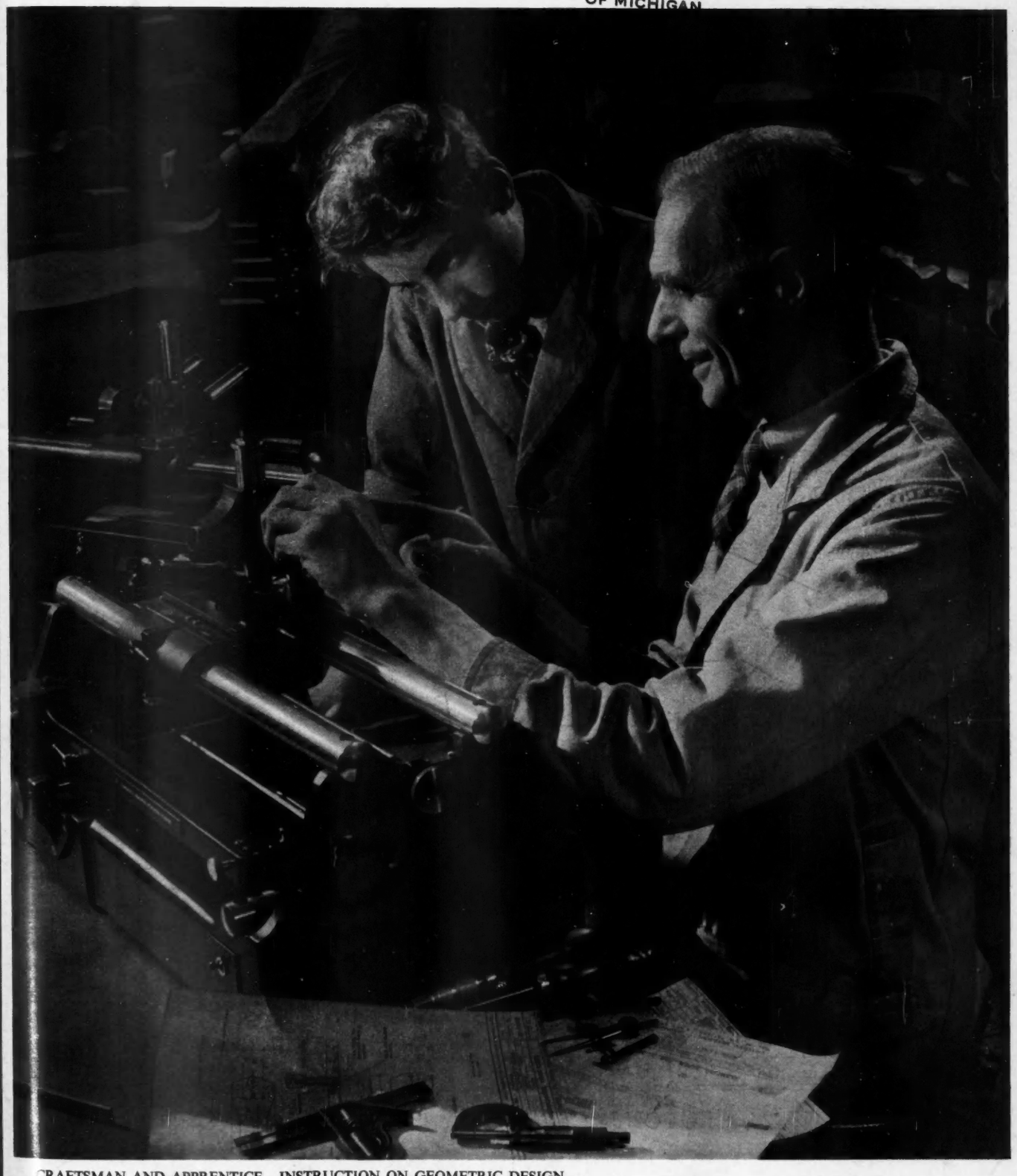

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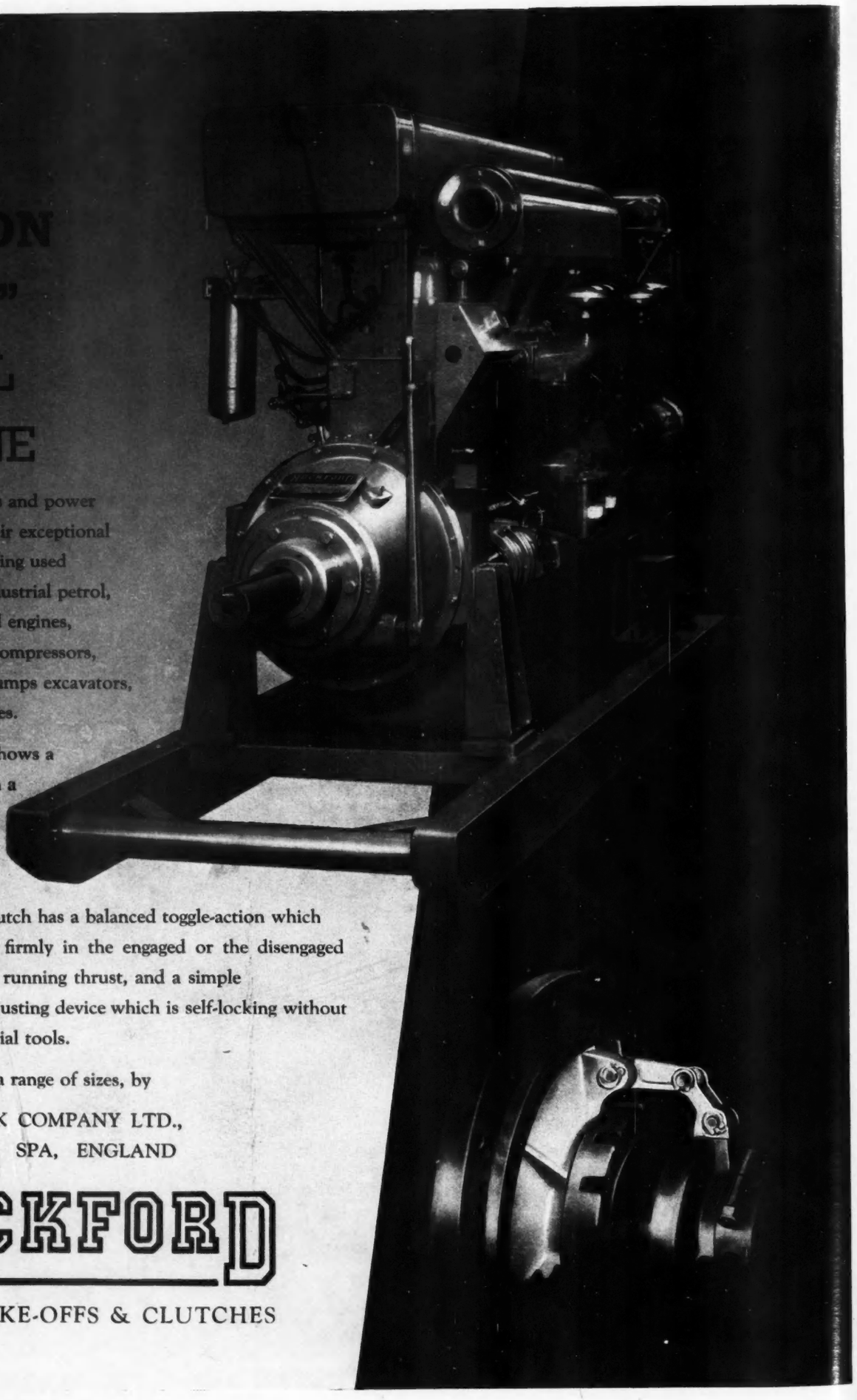

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ENGINEERING

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SCIENTIFIC ENGINEERS

All of that large company which met at the Institution of Mechanical Engineers last Friday will remember, for as long as memory serves them, the remarkable conjunction of things old and things new which the occasion afforded. The chief business (and pleasure) of the evening was the delivery of the James Clayton Lecture, on nuclear reactors and power production, but it was preceded by the unveiling of a bust of James Watt – a ceremony of historical associations which heightened the sense, induced by the Clayton Lecture, of participating in the first stages of a new order of mechanical engineering. How remote James Watt seemed to be; yet how near he was when Mr. G. Nelson Haden, speaking after the unveiling, recalled that "James Watt was the kindly master of my great-great-grandfather."

Mr. Haden's great-grandfather, we learned, was apprenticed to Boulton and Watt, and became one of their chief erectors. He installed the pumping engines at Cranston Hill, Glasgow, and many mill engines in the West of England, and he erected the first municipal gasworks at Leeds. Later he was given Boulton and Watt's agency in the West of England, and on the strength of it, in 1816, he founded the company which bears his name and that of Mr. Haden. Thus mindful of a debt of gratitude to James Watt, Mr. Haden has presented the Institution with a bronze bust of the great engineer. It is a copy of a marble bust, itself a copy of Chantrey's original, which was presented to the Royal Society by James Watt the younger in 1843.

For Watt was a Fellow of the Royal Society, elected in 1785. Dr. E. D. Adrian, the President of the Royal Society, who unveiled the bust, remarked that he was not only the foremost engineer of his day: he was "a brilliant chemist, a worthy companion of Priestley and Keir in the Lunar Society of Birmingham, and one of the first to appreciate the true nature of water as a compound of oxygen and hydrogen." He did more than improve an engine; by doing it he showed how discoveries in physical science could be harnessed for daily use. He improved the Newcomen pumping engine out of all knowledge, because he had learnt of Joseph Black's research on latent heat.

The Institution of Mechanical Engineers honoured his memory by establishing in 1936, when the bicentenary of his birth was celebrated, the James Watt International Medal. This Medal is awarded every second year to an engineer of any nationality who is deemed to merit the highest award that the Institution can confer. Now, at the Institution's headquarters, a James Watt Room has been furnished and decorated, with the bronze bust set in a niche in the wall, and with the names of the recipients of the Medal formally recorded. A George Stephenson Room has also been prepared, in honour of the first President of the Institution. It contains a collection of Stephenson mementoes, including the desk at which he worked. Giving access to these two rooms is the President's Gallery, where pictures of past-presidents are displayed.

With these historical associations newly recalled, the members at the meeting last week made a mental leap to the subject of the James Clayton Lecture. If Watt showed, as Dr. Adrian remarked, how the new discoveries in physical science could be harnessed for daily use, and if he based his engines on his understanding of new physical principles, how much more is this true of the staff of the Atomic Energy Production Department, especially of Sir Christopher Hinton, who gave the Lecture. The problems involved in the design of the Windscale piles, as initially presented to the designers, rarely looked simple. Sometimes, Sir Christopher said, they looked almost frightening in their high content of the unknown. The main skill in designing the piles was to reduce such problems to terms in which they could be interpreted into engineering structures so simple, so well understood, that even the unknown ceased to give cause for alarm.

The close connection between science and engineering was never more amply demonstrated. Indeed it is more than a connection. In the Atomic Energy Production Department it would be difficult to say where one ends and the other begins. It would be truer to say that men of various qualifications and experience, regarded conventionally as physicists, chemists, engineers and metallurgists, come together to evolve, by an integration of minds, unprecedented plant for the production of nuclear power. James Watt showed how direct was the link between science and engineering, but the recognition of this link has faded in recent years. It has been thought that the two branches of learning are quite separate and distinct, whereas, in truth, it has been specialisation in both fields which has made communication difficult. A physicist, however fundamental his work, would probably find it easier to converse with one of Sir Christopher's engineers than with, say, a botanist. James Watt had the right idea, and so did the Royal Society when they made him a Fellow.

Weekly Survey

TIME STUDY

Time study is not synonymous with fixing piece rates for wages payment, though the man on the shop floor – whose pay packet depends on time standards – is fully justified in regarding this aspect of time study as of prime importance.

From the production manager's point of view, however, there are other and more important aspects of time study. Time standards form a basis for scheduling operations to minimise interruptions in the flow of production. Standard costs, derived from standard times, are of great value in estimating and controlling costs. The assessment of material, labour and equipment requirements, and even of delivery dates, is dependent on the accuracy of the original time standards.

A further application of time standards is the measurement of comparative productivity. Though it is difficult to make comparisons for different products, it is possible to compare the standard time for a specified task with the actual time taken. In this way the comparative productivity of different operators can be established, independent of favouritism and prejudice. The best operators can provide a fund of information on working methods ; the worst operators may be improved by closer supervision, or may be transferred to more suitable tasks.

The standard times for the same process in different shops of the same factory, in different factories of the same organisation, and in different organisations also provide a basis for comparing productivity. Though the time spent on the process is important and may be used to measure productivity, improvements in productivity must not be made regardless of costs ; comparison of standard costs will provide additional information which, in some cases, may explain the differences in productivity.

The accuracy of such comparisons will depend on the accuracy with which the original reference time standards were fixed. A survey described in this issue has shown that considerable improvement will have to take place in the accuracy achieved in time-study rating practice before comparisons of productivity become reliable.

The fact, demonstrated by the survey, that large variations exist in ratings given for identical tasks by different observers shows that there is a great deal of disagreement of what constitutes a fair day's work ; there are also great differences in estimates made of production schedules and of the labour, equipment and material needed for a particular task. It is easy to offset fluctuations in the latter by using stocks held in store, but changes in the accepted content of a fair day's work will cause discontent in the shops.

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LEGISLATION ON INVENTION

The Inventions and Designs (Crown Use) Bill, of which we summarised the contents on page 723 of our 176th volume (1953), has come under severe criticism from the Engineering Industries Association. It may be recalled that the Bill, *inter alia*, enables a Government Department to authorise a contractor to use inventions and designs which are not patented or registered, irrespective of any existing agreement; and empowers the Minister of Supply and the Admiralty to demand the disclosure, under penalty, of information relating to any invention or design (whether or not patented or registered) if it appears to be necessary for defence purposes.

The Association protests that the Bill is far too drastic for peace-time conditions, and that the existing Defence Regulations, far from being extended, should be modified. In particular, it is pointed out, there appears to be no Parliamentary control over the issue of directives for the disclosure of information; that the definition of " invention and design " includes all manufacture processes, and that of " defence purposes " covers all circumstances, whether civil or military, in any part of the world.

Under the Bill, directions may be given for information to be passed to any person in any country and thereafter such person can continue to demand further information indefinitely. There is, however, no provision for notifying the person owning the information as to the extent of its use by third parties and no assurance that appropriate payment would be made for such use. A British company might, moreover, be forced to disclose information which had been obtained from a foreign country and might, as a result, run the risk of being sued for wrongful disclosure.

Finally, it is emphasised that the main practical objection to the Bill is that the Government may enforce the disclosure of trade secrets to a competitor – a serious matter which should only be possible under circumstances of a far greater degree of emergency than is envisaged.

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OWEN FALLS HYDRO-ELECTRIC SCHEME

In April, when Her Majesty the Queen inaugurates the Owen Falls Dam and Hydro-electric Station in Uganda, there will be an appreciable load for the station to take over. The Uganda Electricity Board, whose sixth annual report and accounts (for the year ended December 31, 1953) was published this week, hoped that from 1948 to 1954 they would be able to build up a load ready for the Owen Falls Scheme. They did this by ordering 15,000 kW of thermal plant. In his foreword to the report, the chairman of the Board, the Hon. C. R. Westlake, M.I.E.E., remarks that their action has been well justified, since the demand grew from 1·6 MW in 1948 to 13 MW at the end of 1953. The station will thus be able to start with an estimated revenue of £700,000 per annum, and it is confidently expected that by 1962 the Board will have built up sufficient load and will be receiving sufficient revenue to ensure that the hydro-electric scheme is fully self-supporting financially.

The total direct cost of the Owen Falls Scheme, including provision for the civil engineering works required to accommodate ten 15-MW generating sets, and the actual installation of six of these sets, is estimated at nearly £11 million, which is an increase of about 100 per cent. on the estimates in the project report for the scheme. The addition of capitalised interest and head-office management charges will increase the total cost to over £13 million.

The climax to the year's activities at Owen Falls, the report states, occurred on December 23, when the level of the Nile was raised sufficiently to permit the successful operation of the first turbine. The last cofferdam for the main dam was successfully dewatered on June 22, and the last blast in the main dam was fired on August 25. By the end of the year rock excavation was virtually complete. It was expected that the first two 15-MW turbo-alternator sets would be commissioned early this year. The first stage of the 33-kV switching station was almost complete by the end of the year and part of it had been commissioned. The erection of double-circuit 132-kV lines, on steel towers, from Owen Falls to Tororo and from Owen Falls to Kampala was commenced during the year.

Letters to the Editor

KNITTING MACHINERY FOR FULLY-FASHIONED HOSE

Makers' Opportunity

SIR, I read with interest the article " Textile Machinery: Research, Design and Costs," in your issue of February 12, but feel compelled to question the point of view expressed under the paragraph dealing with import licence restriction on fully-fashioned hose knitting machinery. You state that the demand for this type of machinery is weakening, and express disappointment in view of the fact that manufacturers have developed new machines and greatly expanded their capacity in order to obviate the necessity of importing on a large scale from the United States.

I believe that the reason for this weakened demand for British machinery is because the type of machine required, i.e., a multi-section machine, is not being successfully produced in Great Britain. May I venture to say that the expansion in capacity referred to should now be directed towards the building of a multi-section machine before it is too late, for in spite of the relative immunity from American competition, due mainly to the restrictions on dollar imports, this market may yet be recaptured by Germany who were predominant in this field before the war.

It is true, of course, as you state later in your article, that a successful four-section machine is being produced, and it is an excellent machine in its class, but it cannot be regarded as an alternative to the 30-section machine obtainable from the United States, which is faster and over extended tests has proved to be more productive, equally reliable, and less expensive to maintain. It is this type of machine which the majority of the manufacturers of fully-fashioned hose appear to have been demanding for several years.

It is generally felt, I believe, that if the fully-fashioned hose machine building industry is to remain competitive, and so prosper, it will eventually have to produce a successful 30-division machine, and it is my opinion that the building of such a machine is well within their scope. Similarly, from the point of view of the hosiery trade there is much room for improvement in the production of the elements, i.e., the actual loop-forming parts, with which fully-fashioned machines are fitted, and which are consumed in large quantities annually by the trade. Here again, in order to ensure accuracy combined with quality and consistency, it is often necessary to apply for licences to purchase from abroad. Recently the German firms who before the war specialised in this type of component have been making strenuous efforts to recapture their former markets, and it is to be hoped that every effort will be made by British producers to resist these attempts by raising the standard of efficiency of their own manufactures.

While it is appreciated that to bring about the changes advocated in the foregoing paragraphs a great deal of re-tooling and re-planning may be required, I feel that unless this problem is tackled vigorously in the very near future the weakening demand for certain types of hosiery machinery of which you write may continue.

Yours faithfully,

F. W. Prince,
Assistant General Manager.

Bondor, Limited,
Baldock, Hertfordshire.
February 22, 1954.

I.MECH.E. AWARDS

The Council of the Institution of Mechanical Engineers have made the following awards.

The Thomas Hawksley Gold Medal : for the paper on " The Problem of Fuel-Oil Ash Deposition in Open-Cycle Gas Turbines," by Dr. A. T. Bowden, Mr. P. Draper, and Mr. H. Rowling. In view of the scarcity of gold, the medals will be in silver-gilt, and will be accompanied by premiums of £10 each.

George Stephenson Prizes. A George Stephenson Prize, to the value of £30 (accompanied by bronze plaques), for the papers on " An Experimental Single-Stage Air-Cooled Turbine: Part I. Design of the Turbine and Manufacture of Some Experimental Internally-Cooled Nozzles and Blades," by Mr. J. Reeman and Mr. R. W. A. Buswell, and " An Experimental Single-Stage Air-Cooled Turbine: Part II. Research on the Performance of a Type of Internally Air-Cooled Turbine Blade," by Mr. D. G. Ainley.

A George Stephenson Prize to the value of £15 (accompanied by certificates bearing the seal of the Institution), to Mr. C. L. Layland, Mr. A. R. S. Rao, and Mr. H. A. Ramsdale, for their paper on " Experimental Investigation of Torsion in Stranded Mining Wire Ropes."

The Water Arbitration Prize, to the value of £26 (accompanied by certificates bearing the seal of the Institution), to Mr. H. G. Conway and Mr. E. G. Collinson, for their paper on " An Introduction to Hydraulic Servo-Mechanism Theory."

The Starley Premium, to the value of £22 (accompanied by a certificate bearing the seal of the Institution), to Mr. W. M. Heynes, for his paper on " The Jaguar Engine."

The Herbert Akroyd Stuart Prize, to the value of £30 (accompanied by certificates bearing the seal of the Institution), to Dr. F. J. Wallace and Mr. R. W. Stuart Mitchell, for their paper on " Wave Action Following the Sudden Release of Air Through an Engine Port System."

The Thomas Lowe Gray Prize, to the value of £25 (accompanied by a certificate bearing the seal of the Institution), to Mr. H. Hillier, for his paper on " Scale Formation in Sea-Water Distilling Plants and Its Prevention."

The T. Bernard Hall Prize, to the value of £20 (accompanied by certificates bearing the seal of the Institution), to Mr. H. Hampson and Dr. N. Ozisik, for their paper on " An Investigation into the Condensation of Steam."

Engineering Applied to Agriculture Award, to the value of £10 (accompanied by a certificate bearing the seal of the Institution), to Dr. W. R. Berry, for his paper on " An Investigation of Small Helical Torsion Springs."

The Joseph Whitworth Prize, to the value of £40 (accompanied by a certificate bearing the seal of the Institution), to Mr. C. A. Sparkes, for his paper on " Machine Tool Simplification, Especially as Applied to Horizontal Boring Machines."

The Ludwig Mond Prize, to the value of £50 (accompanied by a certificate bearing the seal of the Institution), to Dr. Nicol Gross, for his paper on " Experiments on Short-radius Pipe-bends."

Institution Prizes (accompanied by certificates bearing the seal of the Institution): £20 to Mr. R. A. Fell and Mr. P. Indermuhle, for their paper on " Contemporary Methods of Watch Production." £20 to Dr. Boris N. Cole and Dr. Brian Mills, for their paper on " The Theory of Sudden Enlargements Applied to the Poppet Exhaust-Valve, with Special Reference to Exhaust-pulse Scavenging." £15 to Mr. N. G. Dennis, for his paper on " Water Turbine Governors." £15 to Mr. Sidney Weinberg, for his paper on " Heat Transfer to Low Pressure Sprays of Water in a Steam Atmosphere."

The prizes awarded to graduates for papers read during the session 1952-53 include the following:—

First Viscount Weir Prize (£25) to Mr. T. J. Williams, South Wales Section.

Second Viscount Weir Prize (£15) to Mr. F. A. Smith, Western Section.

ADVANCED TECHNOLOGICAL SHORT COURSES

CO-OPERATION OF FIRMS SOUGHT

" It is of the utmost importance that industry should be made aware that higher technological short courses exist, and equally urgent that industrial organisations should make known what courses are likely to offer the greatest profit to them. They have needs of this kind, why don't they tell us ? " This appeal was made by Mr. S. E. Goodall, M.Sc. (Eng.), M.I.E.E., chairman of the Regional Advisory Committee for Electrical Engineering, at a Press conference called by the Regional Advisory Council for Higher Technological Education (London and the Home Counties), Tavistock House South, Tavistock-square, London, W.C.1, and held on Thursday, February 18.

The conference, which had as its subject " Advanced Short Courses for Scientists and Technologists in Industry," had been called at the suggestion of the Regional Advisory Committee for Electrical Engineering and was concerned especially with courses in that field. Mr. Geoffrey Marchand, C.B.E., chairman of the Regional Advisory Council, presided.

The aim of the conference was to consider ways of securing publicity for courses already formed and for courses to be formed at the request of industry itself. If industry could be encouraged to suggest or initiate courses, then the subjects chosen might have a widespread appeal and the success of lectures, in terms of attendance, would be guaranteed.

In the main address of the conference, Mr. Goodall said that sometimes a course had attracted several hundred students but, at the other extreme, one may have been advertised and not held, because only two or three students had presented themselves. Principals of colleges and heads of departments were usually in fairly close touch with local industry and did their best to provide what seemed to be needed, but they could pursue their activities with greater confidence – and greater success – if industry itself would collaborate more closely in the initiation of courses.

RECENT SCIENTIFIC ADVANCES

He urged firms and industrial organisations to give thought to the importance of keeping their technical staffs in close touch with recent advances in knowledge and to send suggested subjects for short courses to their local college, or to the Regional Advisory Council. When clear suggestions had been made by industry, the resulting courses had usually been among the most successful; but suggestions received had been all too few.

It was not the function of these courses to overlap the standard curricula of universities and colleges but to supplement this knowledge by introducing to industrial technologists, no longer in direct contact with current research, the latest information in their respective fields. Progress since 1939 in radar, television, electronic application, X-ray technology and high vacuum techniques had been abundant and to cope with those advances, numerous special short courses had been instituted since the war.

In the session 1952-53, at least 50 such courses in the electrical field were held in London and the Home Counties, at 20 different technical and university colleges. Most colleges publish leaflets on each special course and the Regional Advisory Council issues twice a year (in July and December) a *Bulletin of Special Courses in Higher Technology* for that area.

A typical series of lectures, announced in the Autumn, 1953, issue of the *Bulletin*, was one dealing with the subject " Crystal Valves and Transistors," and consisted of eight meetings, which took place at the Borough Polytechnic, Borough-road, London, S.E.1, and were addressed by specialist lecturers.

LECTURERS FROM INDUSTRY

In certain cases, advantage may be gained by direct liaison between local industry and a suitably-placed college, in the formation of courses and curricula; but where this is impossible contact with the Regional Advisory Council might profitably be made.

Colleges have given their complete support to the plan and have freely co-operated both in the provision of instructors and of accommodation. Industrial concerns have also proved willing to assist by permitting their specialists to act periodically as lecturers.

During the discussion that followed Mr. Goodall's address, the causes of failure of some courses and success of others were considered. It was believed that whenever a company provided the initial impetus for a series of lectures, the course was well supported, and this was to be expected since industry must know best what its requirements are. It was suggested that the times chosen for lectures might also influence the success of a course.

Dr. G. L. d'Ombrain, of Battersea Polytechnic, proposed that firms should be questioned as to the convenience of various lecture times. Vice-Admiral J. W. S. Dorling, of the Radio Industry Council, suggested that an index of courses should be prepared under subject headings rather than colleges.

In summing up, Mr. Marchand requested that industry be pressed to demand advanced technological short courses. No matter how few of its engineers a particular firm could send on a course and how vague a proposed lecture subject, all contributions would be welcome. Neither a prepared syllabus nor a specific subject was necessarily required; an expression of broad technological needs would be sufficient. The aim of the Regional Advisory Council was to encourage technical colleges to set up courses relevant to local industrial requirements, but it could not succeed in this if these requirements remained unknown.

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SUMMER COURSES AT M.I.T.

The Massachusetts Institute of Technology have announced their plans for special courses to be held during the summer of 1954. In all, 34 special programmes, a series of professional conferences and symposia and more than 100 subjects from the Institute's regular courses will be given " in a form permitting the participation of busy industrial and professional people and providing them with the means of keeping up with recent technical advances."

The courses cover all branches of science and engineering represented at M.I.T. The special programmes, arranged as intensive one-week to four-week courses, will include : analogue and digital computers ; bio-electrical signals ; control problems of the executive ; mathematical problems of communication theory ; operational research ; soil mechanics ; transonic aerodynamics ; and high-temperature ceramics.

INSTITUTE OF METALS

Programme for Spring Meeting

The spring meeting of the Institute of Metals will be held in London from Monday to Friday, April 26 to 30, jointly with the Société Française de Métallurgie, with an extension from May 1 to 4, for members and ladies of the French society.

The meeting opens at the Royal Institution, Albemarle Street, W.1, at 6.30 p.m., on Monday, April 26, when the visitors will be welcomed by the President, Professor F. C. Thompson, on behalf of the Institute and by Professor Sir Cyril Hinshelwood, Foreign Secretary, Royal Society, on behalf of British science. At 7 p.m., Professor L. F. Bates, D.Sc., F.R.S., will deliver the annual May Lecture, on " Magnetic Characteristics of Metals."

On Tuesday, April 27, at 10 a.m., the annual general meeting of the Institute will be held in the Church House, Great Smith Street, S.W.1, where all subsequent meetings are to take place. After the presentation of the reports of Council and honorary treasurer, the President-elect, Dr. S. F. Dorey, C.B.E., F.R.S., will be installed and will deliver his presidential address.

At 2.30 p.m., papers dealing with a " Light Alloy Melting Flux," by Dr. A. H. Sully, Dr. H. K. Hardy and Mr. T. J. Heal; " Effect of Iron, Manganese and Chromium on Properties of Aluminium-Alloy Sheet," by Mr. R. Chadwick, Mr. N. B. Muir and Mr. H. B. Grainger; and " Brittleness in Aluminium-Magnesium-Silicon Alloys," by Mr. I. R. Harris and Major P. C. Varley, will be discussed. While this meeting is in progress, members of the Société will visit works and research establishments in, or near, London.

On Wednesday, April 28, three simultaneous scientific sessions, " A," " B " and " C," will be held, commencing at 10 a.m. Session " A " will take the form of a discussion of a symposium on " The Control of Quality in the Production of Wrought Non-Ferrous Metals and Alloys: Part II. – The Control of Quality in Working Operations." Session " B " will involve a discussion on " Precipitation-Hardening," based on five papers. At Session " C," a discussion on papers on ferrous metallurgy, arranged in co-operation with the Iron and Steel Institute, is to be held.

In the afternoon, at 2.30, the discussion of the Symposium in Session " A " will be continued and, before Session " B," six papers on the theme of " Creep " will be discussed. Meanwhile, members of the Société will visit laboratories and works in the London region. In the evening a banquet will be held.

Two simultaneous scientific sessions, " A " and " B " will again be held at 10 a.m. on Thursday, April 29. At Session " A," an informal discussion on " Recovery and Recrystallisation," organised by the Institute's Metal Physics Committee, will take place. At Session " B " discussions on " Continuous Casting," and on " Molybdenum and Molybdenum Alloys and the Arc Melting of Metals," based on papers yet to be published will be held. In the afternoon, at 2.30, visits will be paid by members of the Société and the Institute to works and establishments in or near London.

On Friday, April 30, all-day visits to Cambridge and to works at Brimsdown, Dagenham, Banbury, Corby and elsewhere have been arranged. Saturday, May 1, will be devoted to an all-day tour to Canterbury. In the evening of Sunday, May 2, members and ladies of the Société will leave London for visits to works and other places of interest in the Birmingham, Cambridge, Sheffield and South Wales areas, arranged for May 3 and 4.

THE NATIONAL FOUNDRY COLLEGE

ADVANCED INSTRUCTION AND RESEARCH

The National Foundry College building at Wolverhampton, which was opened officially by Sir Gilbert Flemming, K.C.B., Permanent Secretary, Ministry of Education, on February 3, represents the first, and major, stage in the provision of permanent accommodation for the College. Extensions to the adjoining Wolverhampton and Staffordshire Technical College, including electrical, electronics and telecommunications, heat-treatment, metrology and work-study laboratories, machine shops, a welding and sheet-metal shop, and a tool room and fitting shop, were also opened at the same time.

The National Foundry College succeeded to the work of its predecessor, the British Foundry School (1935-39), in 1948, using temporary accommodation provided by the Governors of the Wolverhampton and Staffordshire Technical College. In 1953 the necessary expenditure for erecting a suitable building for the Foundry College was sanctioned, and at the same time, a large number of industrial concerns undertook to provide, as gifts, the equipment required for a model foundry.

The new building has been erected as a three-storey wing of the Wolverhampton and Staffordshire Technical College, but although it is connected with the older building, it is a separate unit. Two of the laboratories of the Foundry College are still in the Technical College, and it is intended to provide accommodation for these in an extension to the new building in due course.

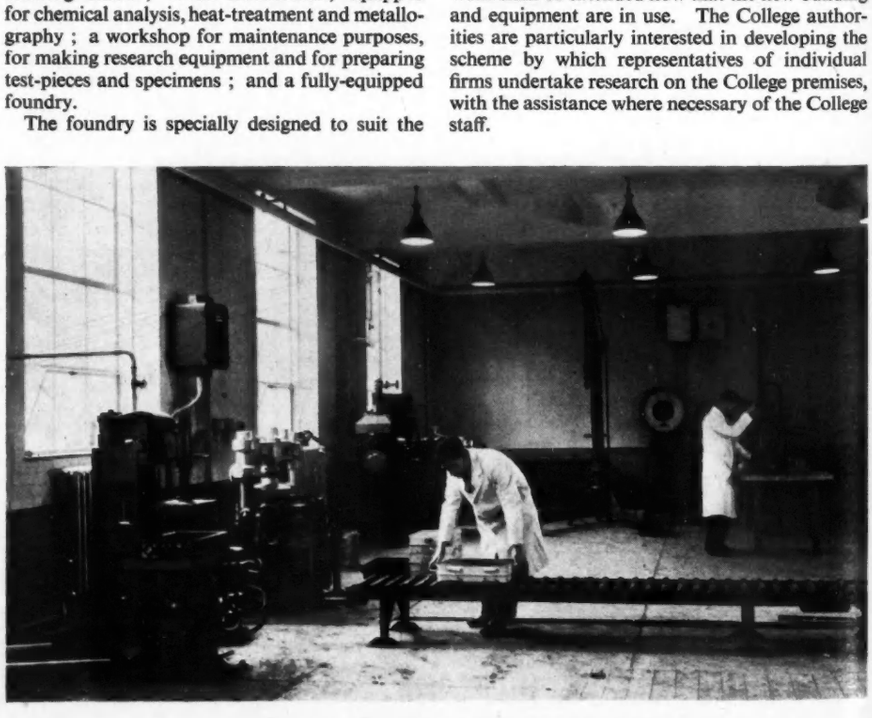
The Foundry College wing concentrates the whole of the College's work, with the exception of the two laboratories mentioned, in a single building. It contains, in addition to the necessary classrooms, offices, dark rooms and stores, two large teaching rooms, with visual-aid equipment, to be used either as lecture rooms or drawing offices; seven laboratories, equipped for chemical analysis, heat-treatment and metallography; a workshop for maintenance purposes, for making research equipment and for preparing test-pieces and specimens; and a fully-equipped foundry.

The foundry is specially designed to suit the teaching requirements of the College, and is provided with a wide range of modern equipment and machinery, to enable any type of foundry operation to be studied. Various kinds of moulding machine are provided, together with facilities for hand-moulding. There are several core-blowing machines, and a core-drying stove. Both ferrous and non-ferrous metals can be melted, the melting equipment including two crucible furnaces, a cupola, a high-frequency electric furnace, and a rocking arc-furnace. Fettling and dressing of castings can be done by hand on suitable benches, and there are, in addition, a power hacksaw, a pedestal grinder with a built-in dust extractor, and a shot-blast cabinet. A fully-equipped sand laboratory adjoins the foundry. Other apparatus installed in the building includes a 250-kV X-ray unit.

Patternmaking facilities, in both wood and metal, are available in the adjoining Technical College premises. It is intended that although the Foundry College is now largely self-contained, co-operation between the two Colleges shall continue, and reciprocal use of equipment is provided for.

The National Foundry College provides the most advanced instruction in foundry technology available in this country. It does not provide craft training, facilities for such instruction being available elsewhere, and students at the College are expected to have obtained experience in a foundry before enrolling for a course. Several different types of instruction are offered, including the Diploma course, Post-Diploma work, and short courses for special purposes. Students are accepted from all parts of the British Isles, and from overseas as well.

In addition to courses for students, the College makes provision for research into all branches of foundry technology, and it is intended that this work shall be extended now that the new building and equipment are in use. The College authorities are particularly interested in developing the scheme by which representatives of individual firms undertake research on the College premises, with the assistance where necessary of the College staff.



Students at work in the new model foundry of the National Foundry College, where techniques and experimental methods can be studied in detail.

PERSONAL

MR. AMBROSE FIRTH, chairman and joint managing director of the Brightside Foundry and Engineering Co. Ltd., Sheffield, has been re-elected President of the Sheffield and District Engineering Trades Employers' Association.

SIR REX HODGES, who is to retire from the position of general manager and secretary of the Mersey Docks and Harbour Board this month, is joining the board of British Insulated Callender's Cables Ltd., as from March 31.

PROFESSOR R. A. RANKIN, Mason Professor of pure mathematics in the University of Birmingham, has been appointed to succeed PROFESSOR T. M. MACROBERT, M.A., D.Sc., who has occupied the Chair of Mathematics in the University of Glasgow since 1927 and who is to retire on September 30.

MR. STANLEY BARR, general manager of the Union-Castle Mail Steamship Co., Ltd., 3 Fenchurch-street, London, E.C.3, retired on February 25 after completing 50 years of service with the company.

SIR EDWARD PARIS, D.Sc., F.Inst.P., chief scientific adviser to the Home Office since 1948, is retiring and DR. R. H. PURCELL, deputy chief scientific officer, Admiralty, is to succeed him as from March 8.

MR. P. R. DREW, O.B.E., T.D., has been elected to the board of Shell Tankers Ltd., and appointed manager of the chartering and freight department.

Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17, announce that, following the transfer of MR. W. L. BEEBY to the Edison Swan Electric Co. Ltd., MR. C. H. SMITH, A.M.I.Mech.E., has been appointed works engineer and MR. J. H. PHILLIPS, assistant works engineer.

MR. E. E. BALDWIN has been promoted to the position of works manager at the High Wycombe factory of Hoover Ltd., Hoover House, 211-213 Regent-street, London, W.1. MR. J. C. SHAPLEY is soon to return to the company's main factory at Perivale as chief production engineer. MR. E. BENNETT becomes production manager and MR. J. T. KING, production engineer, at the Cambuslang factory.

MR. F. J. ALDRIDGE has taken over control of the cable test and research department of Johnson & Phillips Ltd., Charlton, London, S.E.7, in succession to MR. P. M. HOLLINGSWORTH, who is leaving the company to take up another appointment.

MR. S. J. PRESTON, M.A.(Cantab.), A.M.I.E.E., a chief executive officer of the patent department of Electrical and Musical Industries Ltd., Hayes, Middlesex, has been elected vice-chairman of the Council of the Radio Communication and Electronic Engineering Association.

MR. J. S. ELLIOTT, M.I.P.E., Principal of Gateshead Technical College, has been appointed to a similar position at the Rutherford Technical College, Newcastle-upon-Tyne.

MR. R. H. STEPHENSON, O.B.E., director and general manager of Smith's Dock Co. Ltd., North Shields, is to retire shortly after 54 years of service in the shipbuilding and ship-repairing industries of the North-East Coast.

MR. T. R. HAWTHORN, B.Sc.(Eng.), A.C.G.I., has been appointed resident representative of the General Electric Co. Ltd., in Colombia.

MR. J. F. MACGILLIVRAY has been made group personnel manager to the British Tyre and Rubber Co. Ltd., Herga House, Vincent-square, London, S.W.1, and its subsidiary companies.

MR. JAMES ARCHDALE, an executive director of James Archdale & Co. Ltd., MR. BRIAN DAVIDSON, commercial director, Bristol Aeroplane Co. Ltd., and MR. C. E. WRANGHAM, C.B.E., director, C. Tennant Sons & Co. Ltd., and in charge of their chemical and general export departments, have been appointed to the Monopolies and Restrictive Practices Commission. All these appointments are for a term of three years.

MR. NOEL NEWSOME, O.B.E., is to be responsible for public relations and publicity for the Massey-Harris-Ferguson organisation throughout the Eastern Hemisphere and the headquarters of his department is Coventry. MR. A. B. LEES will be in charge of market research in the same department.

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BUSINESS CHANGES

MONO PUMPS LTD. are shortly to move to more extensive premises at Mono House, 1 Sekforde-street, London, E.C.1.

YOUNGS (LIFTING APPLIANCES) LTD., Ryland Street Works, Birmingham, 16, have transferred their London office to 430 The Strand, W.C.2. (Telephone : TEMple Bar 3341.)

TEDDINGTON INDUSTRIAL EQUIPMENT LTD., announce the formation of their group's Midland-area offices at 107 Dale End, Birmingham. (Telephone : Central 4791-2.)

JAMES NEILL & CO. (SHEFFIELD) LTD., Napier-street, Sheffield, 11, have acquired from the Iron and Steel Holding and Realisation Agency the whole of the issued share capital of the HALLAMSHIRE STEEL AND FILE CO. LTD. MR. B. WASDEN will continue as managing director of the latter firm and COLONEL J. P. HUNT and MR. H. W. WATERHOUSE will remain on the board. COLONEL F. A. NEILL, MR. J. H. NEILL, MR. P. NEILL and MR. R. FIRTH will join the board and Colonel F. A. Neill and Mr. J. H. Neill will become chairman and deputy chairman, respectively, of the new board.

On and after March 8, the address of the ASSOCIATION OF BRITISH CHEMICAL MANUFACTURERS will be Cecil Chambers, 86 The Strand, London, W.C.2. (Telephone : COVent Garden 2363.)

MONKS AND CRANE LTD., Birmingham, have moved their Manchester office to more central premises at 8 Wilmslow-road, Manchester, 14.

KINNEAR MOODIE (CIVIL ENGINEERING), LTD., have been made a public company and have acquired the issued share capital of Kinnear Moodie & Co., Ltd., a business which originated over 80 years ago in Glasgow.

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Obituary

MR. WILLIAM LORIMER
A Tradition of Locomotive Building

Mr. William Lorimer, who died on February 18, was the second of three generations of directors who have been active in the building of locomotives for the past ninety years. His son, Mr. William Douglas Lorimer, is to-day a managing director of the North British Locomotive Company, Limited.

Born in Glasgow in 1875, William Lorimer was educated at the Albany Academy in that city, and at Glasgow University. His father, the late Sir William Lorimer, had entered the service of Dübs and Company in 1864, the year after the firm had been founded by Henry Dübs, a former managing partner with the locomotive builders Neilson and Company. He joined his father at the Glasgow Locomotive Works of Dübs and Company in 1897, and six years later, when the firm were merged with Sharp, Stewart and Company, Limited, and Neilson, Reid and Company, to form the North British Locomotive Company, he was appointed one of the first managing directors. His father was chairman of the company on its formation in 1903 until his death in 1922, and he himself succeeded the late Sir Hugh Reid as chairman in 1935. Though he lost his sight in 1926 he continued as chairman and managing director until he retired in 1946. He faced his misfortune with great courage and resolution, continuing to take a leading part in the locomotive industry, and even after his retirement he maintained his keen interest. Last year he was able to join in the celebration of the firm's fiftieth anniversary of its formation and of the 120th anniversary of the completion of the first locomotive built by the oldest of the three firms — Sharp, Stewart and Company.

MR. L. V. DUNLOP
Clyde Shipyard Manager

We record with regret the death of Mr. Louis Vandalle Dunlop, which occurred at Berkhamsted, Hertfordshire, on February 16. Mr. Dunlop, who was 75 years of age, was for many years general manager of the shipyard of Messrs. Harland and Wolff, Limited, Govan, Glasgow, from which position he retired for reasons of health in July last year, soon after completing 59 years of association with the shipbuilding industry. Mr. Dunlop was born at Greenock and educated at Greenock Adacemy. As a youth of 15 he entered the drawing office of Caird and Company in his native town, and subsequently became chief draughtsman and later shipyard manager. In 1915 Messrs. Caird were taken over by Harland and Wolff, Limited, and Mr. Dunlop continued as manager of the Greenock establishment of the company until 1928. In that year he was transferred to Messrs. Harland and Wolff's shipbuilding yard and works at Govan, as general manager, and retained this position for some 25 years.

Mr. Dunlop was elected a member of the Institution of Naval Architects in 1919 and of the Institution of Engineers and Shipbuilders in Scotland in 1928. He served on the Council of the latter institution for a number of years and was also an active member, and at one time chairman, of the Clyde Shipbuilders' Association. After holding various offices in the Shipbuilding Employers' Federation, he was elected senior vice-president in November, 1941, and twelve months later became President for the year 1942-43, in succession to Mr. H. B. Robin Rowell.

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We also regret to record the deaths of the following:

MR. W. H. CARSLAW, M.A., in Stirling on February 20, in his 89th year. He served an apprenticeship in the firm of William Denny and Brothers Ltd., Dumbarton, and was formerly a partner in the firm of Muir and Findlay, boilermakers and engineers, Parkhead, Glasgow.

COLONEL H. J. TORTISE, suddenly at Stockton-on-Tees at the age of 59. He joined Imperial Chemical Industries Ltd., some 26 years ago and was staff manager at the Billingham-on-Tees works of the firm.

LIEUT-COLONEL M. A. WOLFF, O.B.E., J.P., suddenly on February 23 at the Middlesex Hospital. Colonel Wolff, who was in his 72nd year, was chairman of the directors of the Chesterfield Tube Co. Ltd., Derby-road, Chesterfield.

COLONEL J. V. HALL, O.B.E., T.D., A.M.I.C.E., at his home in Sheffield on February 25, at the age of 52. Colonel Hall was sales manager and a special director of Firth-Vickers Stainless Steels Ltd., Sheffield. He served his apprenticeship with Davy Bros. Ltd., Sheffield, and joined the staff of Thos. Firth and Sons Ltd., in 1926.

MR. C. E. NICHOLSON, O.B.E., at his home near Fareham, Hampshire, on February 27, at the age of 85. He was a designer of racing and other yachts and chairman of Camper and Nicholson's Ltd., yacht builders, Gosport and Southampton. Mr. Nicholson was elected a M.Inst.N.A. in 1902, and a Royal Designer for Industry (Royal Society of Arts), in 1944.

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PORT OF ADEN
Development Scheme

The Trustees of the Port of Aden have decided to proceed with an extensive development scheme, for which Sir Bruce White, Wolfe Barry and Partners, London, S.W.1, are the consultants, and contracts for the first stage of the work, amounting to about £2 million are being given to Pauling and Company, Limited, for the civil engineering work, and to the Bridging and Construction Company, Limited, and K. L. Kalis, Sons and Company, Limited, for the dredging.

The proposed development comprises extensive dredging and reclamation together with the construction and equipping of medium-draught and lighterage wharves for the coastal trade.

A feature of the development is to be the creation of a modern trading estate on land which will be reclaimed immediately opposite Somalipura. This estate, with lighterage and road access, will provide sites for packaging, processing and light industrial operations.

ANNUAL DINNER OF THE I.E.E.

Importance of Electrical Equipment in the Armed Forces

The annual dinner of the Institution of Electrical Engineers was held at Grosvenor House, London, on Thursday, February 25, the President, Mr. H. Bishop, being in the chair. There was a record attendance of over 1,300 members and guests.

Proposing the toast of "The Institution of Electrical Engineers," Field Marshal the Rt. Hon. Earl Alexander of Tunis dealt with the ever-increasing importance of electrical engineering to the Armed Forces. In the Navy every imaginable use of electricity was to be found and the Institution had given invaluable assistance in the education of members of the new Electrical Branch. In the Army the electro-mechanical system on the Centurion tank enabled the gun to be held on the target and rapid and accurate fire to be maintained no matter how rough the ground over which the tank was travelling. In the air the applications of electricity would take too long to detail, although it might be mentioned that the larger types of aircraft now carried 2 tons of electrical equipment. In this connection he emphasised the importance of keeping the "knobs and handles" as simple as possible, because the more complicated they were the longer it took to train men to operate them.

In reply, the President agreed that there must be closer collaboration between the fighting men and the engineer if electrical equipment was to be used in the best interests of the country. There seemed to be a grave danger of scientific research being controlled by the demands of defence, but although this might at present be essential it might interfere seriously both with industrial research and with teaching. The three leading engineering institutions had been discussing plans for the development of technological education with the Minister of Education and it was hoped that the result would have a material effect on the supply of fully trained young men. It was clear that more sixth form boys must be persuaded to enter the profession and some better method must be found of matching the number of young men wanting to become engineers to the needs of the industry. He hoped that the Institution and employers would devise a more realistic approach to this problem. The second duty of the Institution was to improve the usefulness of the engineer to the community. Engineers had made life more complex and it was high time they learned better how to live with their inventions and with each other.

The toast of "Our Guests" was proposed by Colonel B. H. Leeson, and Lieut.-General Sir Ian Jacob responded.

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COLOUR TELEVISION LECTURES

In view of the demand for admission to this year's Fleming Memorial Lectures of the Television Society, on "Colour Television," the author, Mr. G. G. Gouriet, has agreed to repeat them. There are two consecutive lectures and they will be delivered on Friday, April 9, and Tuesday, April 13, at the Cinematograph Exhibitors' Association, 164 Shaftesbury-avenue, London, W.C.2, commencing at 7 p.m.

Tickets, admitting to both lectures, may be obtained from the honorary secretary of the Society at the above address. The charge for tickets to non-members of the Society is 5*s*.

ELECTRICITY SUPPLY IN THE NORTH OF SCOTLAND

The annual report of the North of Scotland Hydro-Electric Board* for the year ended December 31, 1953, which has been published more promptly than is usual with such documents, discloses quite a satisfactory rate of progress. Nearly 400 MW of hydro-electric plant, with an average annual output of 950 million kilowatt-hours, is in operation, while rather over 420 MW is under construction and a further 307 MW is in course of promotion and survey.

The annual average output, which it is estimated will be available when the plant under the last two categories is completed, will be 2,357 million kilowatt-hours which is a useful contribution to the electrical requirements of the country. It is further estimated that the potential water-power resources of the Highlands is 10,000 million kilowatt-hours per annum, a figure considerably in excess of the figure of 6,000 million given ten years ago.

During the year the total output amounted to 971 million kilowatt-hours, an increase of 12·5 per cent. over the 1952 figure. The maximum demand, however, was only 3 per cent. higher, which was fortunate as there is still some shortage of generating plant. Rather over 20,000 new consumers were connected in the course of the year. As a result of the comprehensive distribution schemes which have been inaugurated in country districts, one farm and one croft in three have been connected and it is hoped that there will be a steady increase in these directions.

ENGINEERING DEVELOPMENTS

As regards engineering development, 14 power stations are at present under construction, ten of which are on the surface and four are either wholly or partly underground. With the increase in interconnection, six of the stations under construction will contain only one set, thus giving the advantages of simplicity and economy. The dams being erected are of seven different designs and forms of construction and the material being used includes concrete made from blast-furnace slag by the Trief process.

Steps are being taken to have more of the cement required produced in Scotland; and the partial replacement of this material by fly-ash from pulverised-fuel stations is being investigated. Fly-ash, it is pointed out, has no cementitious qualities of its own. It is mainly silicious and acts as a "pozzolan" in combining with the free lime produced in the hydration of Portland cement. It will be rather like the old Roman cement, which was largely made from a finely ground mixture of volcanic ash and lime. In a further attempt to save cement the Allt-na-Lairig dam, which will be 73 ft. high and 1,375 ft. long is being built of concrete prestressed by rods or cables which will hold it down to the rock.

TRANSMISSION DEVELOPMENTS

A considerable mileage of transmission line was placed in service during the year, the most important being that connecting Boat of Garten and Aberdeen via Tomintoul and the Lecht Pass. New lines are also under construction in a number of areas, as well as the necessary substations.

Steam stations are still being operated at Dundee and Aberdeen and played a useful part owing to the small amount of hydro-electric plant which was inaugurated during the year. The capacity of the Diesel stations increased by 3,780 kW, but for economic reasons these stations were more and more used as stand-bys to water power.

* *North of Scotland Hydro-Electric Board. Report and Accounts*, January 1, 1953, to December 31, 1953. H.M. Stationery Office, Edinburgh. (2*s*. 6*d*. net.)

SHIPBUILDING IN 1953

GERMANY LAUNCHED MORE SHIPS THAN THE U.K.

Though Germany led the world in 1953 in the number of merchant ships launched, namely 244, the gross tonnage of these ships was only 818,221, compared with the 1,317,463 tons of the 220 ships launched in the United Kingdom. The world total (excluding Russia, China and Poland) was 1,143 ships of 5,096,050 tons gross. Except for the war period this was the highest figure recorded since 1920. The great majority of the ships (843) were oil-engined, and 22 had Diesel-electric drive. Geared turbines were to be fitted to 142 of the ships; reciprocating steam engines to 117; and a combination of reciprocating engines and turbines to 16. Only two ships, one launched in the United Kingdom and the other in the Netherlands, were designed for turbo-electric drive.

The United Kingdom output was higher than that for 1952 and slightly higher than the average for the past five years, As a percentage of world output (25·9 per cent.) it continued the decline which has taken place annually since the percentage of 56·7 in 1947, though the gross tonnage was still by far the largest of any country in the world. Oil tankers launched during 1953 in the United Kingdom (762,442 tons) showed a substantial increase of 116,414 tons compared with the total for 1952. The 1953 tonnage launched represented 57·9 per cent. of the total U.K. output for the year. Oil tankers represented 55·6 per cent. of all tonnage launched abroad.

Japan was the only country to show a decrease since 1952, when her output was the highest since 1919. The countries abroad with the greatest tonnages of ships launched in 1953 were Germany, Japan, the United States, and Sweden, in that order.

These figures are taken from the *Annual Summary of Merchant Ships Launched in the World During* 1953, published by Lloyd's Register of Shipping.

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NATIONAL DIPLOMA IN AGRICULTURAL ENGINEERING

The written work for the final examination for the National Diploma in Agricultural Engineering will take place from Tuesday to Friday, July 20 to 23, 1954, and will be followed by an oral examination on Tuesday, July 27. Entry forms and further particulars may be obtained from the secretary, the Institution of British Agricultural Engineers, 24 Portland-place, London, W.1; the closing date for the return of entry forms being April 14. The fee for the examination is ten guineas.

LANDSLIDE IN MONMOUTHSHIRE

Blaina, Monmouthshire, a small town in the Ebbw-Fach valley, situated three miles to the north of Abertillery, is the scene of an earth-movement due to the sliding of a mass of clay overlying the parent rocks and thereby threatening to engulf a newly-built housing estate on which over £100,000 has already been spent.

The parent rocks are shales and sandstones of the Lower Coal Series above which is a worked-out seam of the Tillery coal-vein which, in turn, is capped by the Pennant sandstone and the detrital material now on the move. The area affected by this sliding movement is approximately 1,000 ft. by 1,000 ft. with a rise from the advancing toe to the top of the mass of about 350 ft.

The surface of the slowly-advancing area is extremely broken and contorted, the upper portion exhibiting the greatest disturbance, it being broken up into large steps with grass on the "treads" and yellow clay exposed on the "risers." The scale of surface disturbance in the lower portion of the area and where the general slope is flatter, is not so great, although at the leading edge the natural surface has been forced upwards to a height of 10 ft. to 15 ft.

The leading edge of the sliding mass is rounded and, in appearance, is not unlike the leading edge of a slowly spreading viscous fluid ; the leading edge is also cut into by small tongues and valleys from which liquid mud continuously issues in the form of small streams.

CAUSE OF MOVEMENT

The cause of the movement is under investigation but is believed to be the saturation by water of the lower clay layers resulting in very wet conditions at the base, which has thus become too weak to hold the clay on the sloping hillside.

The movement is continuing and the leading edge of the moving mass is now approximately 25 yards from a row of twelve terrace-type houses, all but one of which have been evacuated. If this line of cottages is engulfed, a serious situation will arise as the newly-built housing estate, which lies at a lower level, will be threatened, the distance between the cottages and the nearest of the new houses being but 100 yards down a steep slope.

The position is causing anxiety to the Nantyglo and Blaina Urban District Council and to the Ministry of Housing and Local Government. Mr. W. B. Davies, M.I.C.E., consulting engineer, Cardiff, Mr. M. Nachsen, M.I.C.E., consulting engineer, London, and Professor A. W. Skempton, D.Sc., A.M.I.C.E., of the Department of Soil Mechanics of the Imperial College of Science and Technology, London, are being consulted.

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BRITTLE FRACTURE IN STEEL

Report of Conference

A report of the Conference on Brittle Fracture in Steel, organised by the West of Scotland Iron and Steel Institute and held in Glasgow in May, 1953, has been published in volume 60 of the *Journal* of the Institute. Copies of the *Journal* may be obtained from the Institute, 39 Elmbank-crescent, Glasgow, C.2, at 50*s*. each, or copies of the report, reprinted from the *Journal*, are available at 40*s*. each. A report of the discussion following the Conference is also included, but as the discussion took place on the whole group of papers, reprints of individual papers have not been made. A brief report of this Conference was given in ENGINEERING, vol. 176, page 70 (1953).

INNOVATIONS IN COALMINING

NATIONAL COAL BOARD'S EXPERIMENTS

The use of aluminium cages, battery locomotives, radio-telephones and portable vacuum cleaners for reducing dust were among the innovations now being introduced into coal mines described by Mr. E. H. Browne, C.B.E., M.A., director-general of production, National Coal Board, in a lecture to the Midland Branch of the National Association of Colliery Managers on Tuesday, February 23.

A very considerable part of the lecture was devoted to recent developments in blasting, coal-getting and loading away. Firing over 90 million shots each year, the Board spends over £6½ million per annum on the materials apart from the labour involved and this was said to be a particular aspect of mining where technical development could lead to increased safety, improved efficiency, reduced degradation (and thus enhanced value of the coal produced) together with an immediate reduction in costs. Though improved techniques in the use of explosives could offer quick results, the newer and alternative systems to blasting would appear to offer the possibility of the greatest improvement in the more distant future. The alternatives, various forms of power-cutting and power-loading machines, together with modern conveyor systems were illustrated by about 20 slides.

PROVING COAL SEAMS

Mr. Browne began his lecture by referring to the possibility of proving coalfields which extend below the sea bed by putting down bore holes from platforms not dissimilar to those erected for sea forts during the war. It is intended that suitable platforms (the form of the platform and tower is shown in the accompanying illustration) should be floated out to the site and then mounted on towers designed for any depth of water up to about 20 fathoms. This should be sufficient for boreholes located within a distance of 3½ miles from the shore along the north-east coast of Britain where valuable seams are known to extend beyond the Firth of Forth and the Durham and Northumberland fields. It was also thought that anthracites lie under the Channel, being outcrops from the Kentish mines.

As well as the special drilling rig, winch, and drill bars, a small power station, with Diesel-electric set, and living accommodation, would be provided on the platforms. The first bore-hole is to be put down off the coast of Fife and if the equipment and method are found to be successful, a long programme of work will be scheduled.

Irrespective of the success or otherwise of off-shore boring, drilling from the surface would still remain the primary means of gaining information about unexplored seams. Research into drilling techniques, particularly in respect of cutting-bits, the bearing weight allowed on the drill, rates of rotation and types of core barrel and core catcher, had resulted in a great improvement in the proportion of core recovered for examination. Furthermore, a continuous record was now taken of the rate of penetration; and since every type of rock offered a different resistance to a drill under a given pressure, the rock junctions were clearly determined. As coal was penetrated more easily than other carboniferous rocks the location and thickness of coal seams was found with some precision.

The value of bore holes could be further enhanced by the continuous recording of such factors as electrical resistivity and radioactivity of the strata drilled; the graphs so obtained were known as Schlumberger logs. Given one cored bore-hole in any district so that Schlumberger observations might be related to local strata, it was then sufficient to rely solely on such observations from all other bore-holes in the vicinity, so avoiding the cost of gaining cores from every boring. Although such techniques were not novel, in the sense that they had been used for many years when prospecting for oil, their application to coalfield boring was quite new, and changes and refinements in the techniques have had to be made for this purpose.

ALUMINIUM CAGES

The reduction in the weight of cages by the use of a light alloy instead of steel had obvious advantages. For a particular output it made possible the use of ropes and winding-drums of smaller diameter, and gave some economies in the initial cost of installation and in power consumption for winding even from average depths. It also helped to solve the general problems involved in winding from great depths which were expected to increase in the future; it might also have a particularly useful application where existing winding equipment was required to wind from a lower depth or with heavier loads.

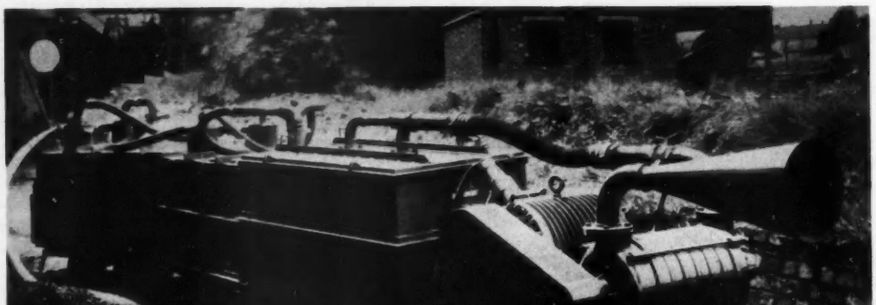
The first step was the use of composite aluminium and steel cages first installed about four years ago. The cages had lasted as long as steel ones and were still in good condition, but maintenance costs had been higher, largely because composite cages needed to be painted often to limit corrosive interaction between the two metals. Steps were now being taken to construct an all-alloy cage using new techniques for riveting and welding aluminium.

MECHANICAL MUCKING IN NEW SHAFTS

For sinking new shafts a greater use was to be made in the future of concrete for shaft lining in frozen strata. Though used abroad, this would be a new departure in the United Kingdom and it would be adopted in two instances at least: the Lea Hall sinking in Cannock Chase and at Bravercotes in Nottinghamshire.

The possibilities of mechanical mucking had been studied and important developments in South Africa had been watched with interest. Use was made of a sinking platform comprising three stages or floors. On the top stage a concrete bucket was operated; concrete was delivered into a chute and thence into an "octopus" from which it was fed down to the middle deck and to the periphery of the shaft through three tubes. The middle stage was used

Important coal reserves lie off Britain's coasts. Platforms such as this are to be used for putting down boreholes to prove the extent and nature of the seams.



This experimental mobile vacuum cleaner has recently been tried in two West Midland collieries. Coal dust – a source of danger to health and a potential explosive – can be collected from where it has settled in roadways and on structures.

by the men who placed the concrete and lowered the shuttering. The bottom stage carried the blasting, lighting, telephone and signalling cable drums. Attached beneath the bottom stage, and suspended from a mono-rail, was apparatus for manipulating the cactus grab which consisted of gears, motors, etc., and the driver's cab.

The cactus grab itself was an important feature of the equipment. It was of 20 cub. ft. capacity, weighed 5,500 lb., and had eight jaws, operated by compressed air. With an overall width (when closed) of 5 ft. 7 in. and a total spread of 7 ft. 3 in., a 5-ton capacity kibble could be filled in 3½ to 4 minutes. The conditions prevailing in South Africa were vastly different from those found in this country; in particular, no side supports were used and heavier charges of explosives could be fired. In spite of the differences it was thought that these methods might well be adapted to suit the conditions existing here.

COMMUNICATIONS

There were several possible applications of radio equipment both on the surface and underground. V.H.F.-radio telephones had been installed for communication between rescue stations and their vans. This apparatus could be used, of course, for routine purposes, but it might be of particular value during an emergency when telephone lines were overloaded or damaged. Similar equipment could be used for the control of shunting in large sidings, and in the maintenance of aerial ropeways and overhead power lines.

Below ground normal radio communication appeared to be impracticable, but wired-radio communication was promising. The experiments had now reached a stage where further information should be obtained from large-scale trials. This method of communication might well be found useful for such purposes as shaft inspection and repair work, for underground locomotive control, for endless-rope manriding haulages and other similar applications. Equipment should be available in prototype form this year.

Underground telephone equipment and installations were as yet often unsatisfactory for present-day needs. Automatic systems were available only for small installations, and a fully automatic system sufficient in capacity for a large mine would be valuable. This equipment must, of course, be flameproof and intrinsically safe. New electronic devices, such as germanium valves, might assist this development.

VACUUM DUST COLLECTION

The defence against coal dust was to avoid making it or to suppress it at the face; but there was also a need for more efficient means of collecting it when deposited on roadways, conveyor structures, and so on. It had been decided therefore to develop experimentally a portable vacuum cleaner for this purpose.

The experimental unit, shown in the illustration above, was built around a multi-stage turbo-exhauster driven by an 8½-h.p. electric motor. The pick-up is through a flexible hose, and the mixture of air and dust passes through steel containers incorporating cyclones and multi-bag filters, to prevent dust and fragments of coal from entering the exhauster. The first trial machine was found capable of dealing with 2 to 5½ tons per hour of material up to 2 in. in size. The suction velocity was about 90 ft. per second.

Modifications had now been made to limit the size of the material to ½ in. to avoid danger from sparking and to make better use of the available capacity. Gas vents were being fitted to the containers, and the fabric in the bag filters was to be flame-proofed and rot-proofed, in order to prevent deterioration of efficiency. The use of the vacuum cleaner was at present restricted to roadways without conveyors, but it was hoped that forthcoming trials would show that the machine could be used with safety, and thus employed for other applications, including conveyor roadways.

ROADWAYS

Over 600,000 manshifts were at present employed each year on the more important tunnels, and when some of the new horizon mines were extended, tunnelling work would be on an increasing scale. The need for a road-boring machine had long been felt and numerous attempts had been made to develop one.

At present, work was being carried out on the American Marietta miner, shown in the photograph below, which was designed for driving coal headings. For tunnelling work it would need substantial modification, and the two machines brought over from the United States were to be regarded primarily as a basis for development. The first machine had been used experimentally in Scotland, and had given important information, but a major re-designing task remained. The need for a tunnelling machine, however, was very great and there was every justification for a concentration of effort on it.

CENTRAL ENGINEERING ESTABLISHMENT

Mr. Browne concluded by referring to the Central Engineering Establishment which was going to be set up by the Board near Bretby primarily for the purpose of developing new machinery and equipment, but also for testing and inspecting plant and materials used at collieries.

Facilities would be made for developing supports, machinery and equipment for the coal face and tunnels; for handling equipment on the roads, in the shafts, and on the surface; for coal preparation plant; and for all the subsidiary processes used in getting coal from the mine face to the railway wagon.

* * *

BAYLISS PRIZE

I.C.E. Award

A Bayliss prize of £15 has been awarded to Mr. Colin Gordon McMillan, Stud.I.C.E., Southland, New Zealand, who gained the first place, in order of merit, at the associate-membership examination (parts I and II) of the Institution of Civil Engineers, held in October, 1953. Mr. Robert William Smith, Stud.I.C.E., obtained second place and was awarded an honourable mention. Results at British and overseas centres were taken into account.

This "Marietta" miner from the United States is being used experimentally in a Scottish colliery. It is to be re-designed and modified for use in tunnel work.

Book Reviews

Watch and Clock Making and Repairing. By W. J. GAZELEY, F.B.H.I. *Heywood and Company, Limited, Tower House, Southampton-street, Strand, London, W.C.*2. (42*s.*)

Switzerland exports some 25 million watches per annum. The same thing certainly cannot be said about Great Britain and yet in the Eighteenth and the early part of the Nineteenth Centuries, England stood in the front rank of the watch-making countries of the world. The decline of the industry was such that about the time of the first World War English watch-making was almost moribund. This was certainly not due to any decline in the quality of the product ; many Nineteenth-Century English lever watches are still giving good service. The reason was, perhaps, the opposite ; the watches were too good, or more correctly, too expensive. The introduction of the cheap mass-produced American watch was to a considerable extent responsible for the extinction of the once flourishing watch-making industry in Liverpool.

It is that term " mass-produced " which explains the whole matter. Sub-division of labour in the English watch-making industry was by no means unknown even in the Eighteenth Century, but the employment of automatic machines and repetition manufacture, with their attendant possibilities of great accuracy and high output, was neglected. Early practice of modern methods, coupled with cheaper labour than ruled here, enabled Switzerland to build up her present commanding position in Europe.

There is nothing in the Swiss climate making it peculiarly favourable for the manufacture of watches, and it is a matter for much satisfaction that in recent years able and successful attempts have been made to revive watch-making in Great Britain. Watch-making is now a precision-engineering job; the major part of the operations are carried out by semi-skilled labour on highly-specialised machines, but such a system of manufacture requires a nucleus of craftsmen to control and direct. Mr. Gazeley has provided an admirable text-book for the instruction and guidance of the skilled tradesmen on whom the successful operation of this highly-technical industry depends.

It is not only in the factory that craftsmen are necessary. Watches have to be maintained and repaired, as well as made. There are hundreds of retail shops in this country which carry the legend " Watchmaker and Jeweller," but it may be confidently surmised that few (probably none) of the proprietors of these shops *make* watches. They, however, undertake to repair and clean them. It will be to the advantage of most of them, and to their customers, if they will buy and study this book.

Mr. Gazeley is not concerned to deal with the organisation, lay-out and operation of a watch-making factory. It is his purpose, carried out with remarkable thoroughness, to describe, in meticulous detail, the nature of the almost endless variety of watch mechanisms and the methods of machining or repairing the parts thereof. The practical nature of his book is indicated by the fact that the first chapter is devoted to a detailed description of the tools and equipment necessary for watch and clock work and the second to the materials with which the worker has to deal. This is followed by chapters on watch and clock movements, the rest of the book being concerned with the design, manufacture and repair of the many hundreds of different detail parts with which a worker may have to deal.

It is probable that many of the watches dating from the Sixteenth or Seventeenth Centuries, which are to be seen in museums and private collections, were made throughout by a single worker who cut the wheel and pinion teeth by hand. Although it is likely that many of these products did not keep very accurate time, and possibly did not run for many hours with one winding, they are outstanding examples of the possibilities inherent in trained craftsmanship. The modern watch repairer will, in general, expect to obtain spare factory-made wheels and pinions, but Mr. Gazeley, who points out that a worker may have to deal with old watches, or clocks, as well as modern ones, gives full instructions about cutting toothed-wheels and pinions and, as may be necessary in special cases, making the necessary cutters.

The whole range of watches is covered in this admirable and lavishly illustrated book. Chronometers, chronographs, repeaters and self-winding watches are fully dealt with. These latter, although now expensive, may be expected to increase in popularity. They have the advantage that for the greater part of the 24 hours they are fully wound, which contributes to accurate timekeeping. The above remarks have been mainly confined to watches, but Mr. Gazeley deals equally with clocks. These represent a branch of industry in which this country has held its own rather better, but the spring-driven domestic clock is now faced by a formidable competitor in the electric clock.

Handbook of the Fan Engineering Industry. *The Fan Manufacturers' Association, Limited,* 59-62 *High Holborn, London, W.C.*1. (3*s.* 6*d.*)

This handbook has been produced to convey a general impression of the fan engineering industry and is not intended to refer to all the applications of fan equipment. It is intended to form a link between users and manufacturers.

Starting with a brief note on the aims and origin of the Association, the book continues with a list of buildings and operations for which fans are required. Types of fans are then discussed, and the choice for different applications considered; performance curves are also given. There is a large section dealing with ventilation and air conditioning in which the special problems arising with industrial and assembly buildings, and ships' accommodation and cargo spaces, are dealt with. The ventilation of mines and of tunnels have separate sections.

In industry, dust and refuse removal is required under the Factory Act and fans are needed for this as well as for removing fumes. Drying is another process for which the movement of quantities of air is required. Pneumatic conveying plays its part in many processes and various aspects are considered. Finally, the book gives a useful guide as to the particulars that should be stated in inquiries and orders.

Protection of Subgrades and Granular Bases by Surface Dressings. Road Note No. 17. *Department of Scientific and Industrial Research. H.M. Stationery Office, Kingsway, London, W.C.*2. (9*d.*)

The prepared formation of a new road can be badly damaged during wet weather before the pavement is laid, as the surface of the subgrade, softened by rain, is easily churned up by construction traffic. This new Road Note describes the experience of the Road Research Laboratory and gives the Laboratory's recommendations for providing surface dressings for various types of soil formation and bases. Details are given of the number of dressings required and the types of binder and aggregate, with the appropriate rates of application.

Post Office London Directory 1954. *Kelly's Directories, Limited,* 186, *Strand, London, W.C.*2. (100*s.*)

The 1954 edition of the Post Office London Directory, completely revised, follows the familiar arrangement of previous years. In addition to the detailed street directory and large map of London, it contains valuable alphabetical and classified commercial, professional and trade sections. It also includes an official section giving particulars of the Royal Household, Government and other public offices, and ambassadors; and sections on law, selected private residents' addresses, a parliamentary directory, a postal directory, a city, municipal and parochial directory, an ecclesiastical directory, a transport directory and country gazetteer, and a directory of bankers.

Trade Publications

Machine Tools. Complete details of machine tools marketed by Newman Industries, Ltd., Yate, Bristol, are given in their illustrated stock list, which covers capstan, combination and automatic lathes, gear cutters, millers and other standard machines, together with certain less familiar ones. A Cincinnati Hydromatic milling machine with three adjustable heads; a Rocco horizontal boring machine; and a Heid Sensitast universal copying lathe are described.

The Continuous Measurement of Steam Purity. The Melesco " Salagraph," which is explained with illustrations in a booklet sent to us by the Superheater Co., Ltd., 53 Haymarket, London, S.W.1, provides a method of continuously determining – by means of electrical conductivity measurements – the concentration of dissolved salts in steam. The apparatus, which can be supplied as a portable or static unit, secures the prior elimination of gases such as ammonia and carbon dioxide, after which the conductivity of the degasified and condensed sample is registered by a Kent Multelec conductivity recorder.

Control Valves. The Crosby Valve and Engineering Co., Ltd., have issued an illustrated catalogue giving particulars of Masoneilan control valves that they manufacture under licence from the Mason-Neilan Regulator Co., Boston, U.S.A.

Office Furniture. Particulars of office seating are given in an illustrated leaflet issued by Evertaut, Ltd., Walsall-road, Perry Barr, Birmingham, 22B.

Electric Motors for Home and Export. A leaflet issued by the A.E.G. Electric Co., Ltd., 131 Victoria-street, London, S.W.1, gives a general description of their range of electric motors from ¼ to 200 h.p. A second leaflet gives their export price list.

Helical Gear Units. An illustrated and informative catalogue of helical and turbine gear units, complete with a description of their manufacture and tables of dimensions and horse-power ratings, has been issued by the David Brown Corporation, Ltd., Gear Works Division, Park Works, Huddersfield. Of special interest is a gear-type flexible coupling, which can accommodate various errors in shaft alignment.

★ ★ ★

Books Received

Heat Transfer by Radiation. By J. H. MCGUIRE, B.Sc., A.Inst.P. *H.M. Stationery Office, Kingsway, London, W.C.*2. (1*s.* 6*d. net.*)

Some Important Developments During 1953 in Iron and Steel Technology. (1 Swiss franc, or 1*s.* 9*d.*) **The European Steel Market in 1953.** (2·75 Swiss francs, or 5*s.*) United Nations Economic and Social Council, Economic Commission for Europe. *United Nations, Palais des Nations, Geneva, Switzerland* and *H.M. Stationery Office, Kingsway, London, W.C.*2.

Test and Certification of Intrinsically Safe Electrical Apparatus and Circuits. *H.M. Stationery Office, Kingsway, London, W.C.*2. (6*d.* net.)

Admiralty Ship Welding Committee. Third Interim Report. *H.M. Stationery Office, Kingsway, London, W.C.*2. (2*s.* net.)

Chimie Analytique Appliquée à la Métallurgie. By M. HUYBRECHTS. Third edition revised by PROFESSORS R. CHANDELLE and C. VANDAEL. *Masson et Compagnie,* 120 *Boulevard Saint-Germain, Paris* (6e). (2,800 francs.)

Ciments et Bétons. By J. CLÉRET DE LANGAVANT. *Librarie Armand Colin,* 103 *Boulevard Saint-Michel, Paris.* (250 francs.)

Spheroidal Graphite (Nodular) Cast Iron. By JOHN SMUTS, B.Sc. *The Association of Engineering and Shipbuilding Draughtsmen, Onslow Hall, Little Green, Richmond, Surrey.* (3*s.*)

Discontinuous Automatic Control. By DR. IRMGARD FLÜGGE-LOTZ. *Princeton University Press, Princeton, New Jersey, U.S.A.* (5 dols.), and *Oxford University Press* (*Geoffrey Cumberlege*), *Amen House, Warwick-square, London, E.C.*4. (32*s.* 6*d.*)

Densening and Chilling in Foundry Work. Ferrous and Non-Ferrous Casting. By EDWARD LONGDEN. *Charles Griffin and Company, Limited,* 42 *Drury-lane, London, W.C.*2. (28*s.* net.)

Oil in the Soviet Union. History, Geography, Problems. By HEINRICH HASSMANN, translated by ALFRED M. LEESTON. *Princeton University Press, Princeton, New Jersey, U.S.A.* (3·75 dols.), and *Oxford University Press* (*Geoffrey Cumberlege*), *Amen House, Warwick-square, London, E.C.*4. (30*s.* net.)

The Engineering Outlook—9

SHIPBUILDING AND MARINE ENGINEERING

GREATER OUTPUT: FEWER ORDERS

In many ways, the outlook for British shipbuilding is disquietening, but the larger firms of shipbuilders, at least, are assured of a high output for some years yet. Supplies of steel plate have been improving steadily and, though some work was still being held up during the last quarter of 1953 because the right sizes and types of steel plate were not forthcoming, these shortages have now been largely overcome. The output in 1953 was not much higher than in 1952, as shown in the accompanying graphs and Table I, taken from the shipbuilding returns of Lloyd's Register, but Mr. J. P. L. Thomas, First Lord of the Admiralty, has said that all possible action was being taken to increase the supply of plate to the yards, so that launchings in 1954 may reach 1·5 million tons gross. This compares with the 1·3 million tons per annum achieved during the past three years, but still falls short of the full potential in the United Kingdom of 1·75 million tons. Faster and more economic construction in 1954, however, should help British shipbuilders to counter competition from foreign builders, who, largely because of their ability to give quicker delivery, have been gaining an increasing share of world business in recent years. Some of these foreign yards are heavily subsidised, whereas British builders can hope to keep their prices competitive only by raising their efficiency.

All the main shipping companies have complained during the past two or three years of the high cost of shipbuilding, and this has been one of the factors responsible for the fall in orders for new tonnage. The downward trend had already begun in 1952, when new orders booked amounted to 1·7 million tons compared with 4 million tons in 1951; but it was greatly accelerated in 1953, when they amounted to only about 500,000 tons. There is still a total of 6 million tons of new shipping on order, so that it may seem somewhat premature to worry about the future of the industry; but whereas the bigger yards, particularly those capable of building large tankers, may take up to four years to get through the work in hand, many of the smaller shipbuilders will need to book orders very soon to take the place of work nearing completion.

Even the larger shipbuilders have little security, however, for the threat of cancellations is constantly before them; the memory of wholesale cancellations as the slump deepened in 1930 is still vivid, and already orders for 200,000 tons of shipping have been cancelled. Further cancellations are likely if costs rise and it becomes clear to shipowners that they will be required to pay considerably more for their new vessels than they had expected: the consequences may be serious, therefore, if the engineering and shipbuilding unions succeed in pressing their claims for a 15 per cent. increase in wages. It is not so much the absolute level of shipbuilding costs which is important, of course, as their relation to the prospective earnings of the new ships when they go into service; and the continuing low level of freight rates, both for tanker and dry-cargo tonnage, gives shipowners no inducement to order replacements for the large volume of over-age tonnage at sea to-day.

LOW SHIPPING EARNINGS

The index of freights for tramp shipping (average for 1952 = 100) never exceeded 86 in 1953, and for the last six months of the year was considerably below this, falling to 71·5 in December, compared with 146·4 in January, 1952. As a result, the amount of tonnage laid up as uneconomic is increasing and the prices of second-hand vessels have fallen markedly. A Liberty-type vessel sold in the second half of 1953 fetched only £180,000, whereas similar vessels were selling for more than £600,000 at the end of 1951. Moreover, the British dry-cargo fleet has been contracting; in 1953 it amounted to 13·9 million tons gross, compared with 14·1 million tons in 1952.

Particularly disturbing is the decline in the tramp fleet, which is now only about 2·4 million tons; 400,000 tons less than in 1951 and a million tons less than in 1939. The implications for a country dependent upon the mercantile marine for its existence in war and for important earnings of foreign currency in peace are serious. It is estimated that these earnings amounted to £225 millions in 1952, and though, with the fall in freight rates, they must have fallen off considerably in 1953, shipping still remains one of the most important British export industries.

The decline in the British merchant fleet in 1953 occurred despite an increase of 7 per cent. in the tonnage of shipping entering British ports. Even so, this was 5 per cent. less than in the immediate pre-war years and, as the Council of the Mercantile Marine Association have reported, the present British tramp fleet, while much smaller than it was 15 years ago, may be sufficient for requirements "of ordinary peace-time trading." Its efficiency and age distribution, however, leave much to be desired; Viscount Runciman has estimated that, in the next 10 to 12 years, something like half of the British merchant fleet will disappear by old age or obsolescence, and must be renewed. This alone should ensure sufficient work for British yards for as far ahead as it is reasonable to look, and many foreign merchant fleets are in the same condition as the British.

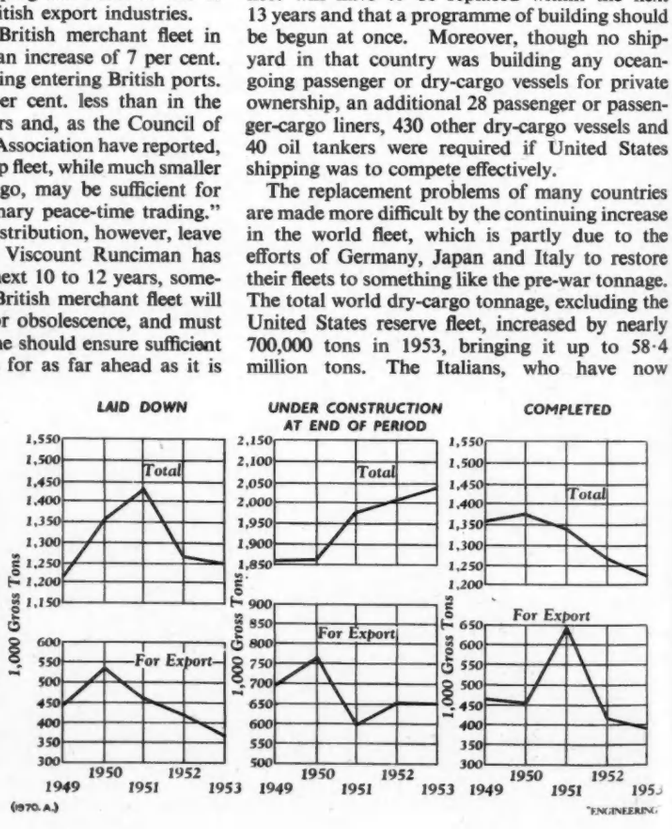
Foreign owners, however, are at present as reluctant to order new tonnage as the British. Danish shipping earnings in 1953 are expected to be £15·5 millions less than the total of £63·5 millions achieved in 1952, and, with 25 out of their fleet of 566 vessels laid up, Danish owners contracted for no new tonnage in 1953. Swedish shipping earnings in 1952 amounted to £65 millions, but in 1953 are expected to have been about one-third lower. Some Swedish owners have sold ships because they could not operate them economically. They complain that Swedish law compels them to man their ships with larger crews than, for example, the Germans.

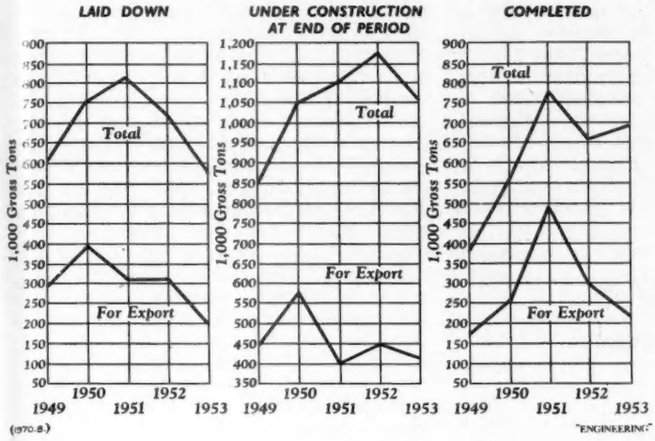
FOREIGN FLEETS

The problem of high operating costs is even more serious for United States and Canadian owners. The British Government have agreed to a request from the Canadian Government for permission to transfer further Canadian dry-cargo tonnage to the British registry because it can no longer be worked economically without subsidy if manned by Canadian crews, whose standards of wages and working conditions are second only to those of the United States merchant marine. The latter is heavily subsidised, but, nevertheless, has suffered severely from the slump in freight rates; in January, 1953, United States vessels carried only 25·9 per cent. of the foreign trade of the United States, compared with 43·6 per cent. in January, 1952. Between July, 1952, and July, 1953, another 500,000 tons of shipping were added to the United States reserve fleet of laid-up vessels, mainly of the Liberty type, bringing its total to 13 million tons. A high proportion of the ships still operating were also built in war-time, and their retirement is advocated by the 15 shipping companies responsible for the publication of the bulletin, *Maritime Affairs*. In this it is stated that 83 per cent. of the United States merchant fleet will have to be replaced within the next 13 years and that a programme of building should be begun at once. Moreover, though no shipyard in that country was building any ocean-going passenger or dry-cargo vessels for private ownership, an additional 28 passenger or passenger-cargo liners, 430 other dry-cargo vessels and 40 oil tankers were required if United States shipping was to compete effectively.

The replacement problems of many countries are made more difficult by the continuing increase in the world fleet, which is partly due to the efforts of Germany, Japan and Italy to restore their fleets to something like the pre-war tonnage. The total world dry-cargo tonnage, excluding the United States reserve fleet, increased by nearly 700,000 tons in 1953, bringing it up to 58·4 million tons. The Italians, who have now

Merchant shipbuilding in the United Kingdom: the data relate to vessels of 100 gross tons and over. Output, hitherto restricted by the steel shortage, may rise considerably in 1954, but as fewer orders are now being placed, the outlook for subsequent years is not promising.





Tanker construction in the United Kingdom: the data relate to vessels of 1,600 gross tons and over. Output in 1954 may be a record but the declining trends indicated in the second and third graphs show that the tanker boom is over.

brought their fleet back to the pre-war total of 3·5 million tons, have announced their intention to add a further 500,000 tons in the next two years. The Japanese fleet still totals only 2·3 million tons, compared with 6·3 millions before the war, but it is proposed to increase it to 4 million tons within the next four or five years. The German merchant fleet, at 1·8 million tons, is 2·7 million tons smaller than before the war, but the German Government have repeatedly affirmed their intention to bring it up to 3·5 million tons. Since comparable expansions in the world sea-borne trade are unlikely, the effect of all these building programmes must be to depress freight rates further, and may mean the withdrawal without replacement of older vessels under the British flag or on the registers of foreign owners who have been accustomed to look to British yards for their replacements.

INADEQUATE DEPRECIATION ALLOWANCES

Government action could do much towards maintaining the size and efficiency of the British merchant fleet. Subsidies are not required, though, in view of the assistance given to air transport, shipowners may feel a little aggrieved. First-class passenger bookings on the world sea routes have been seriously affected by competition from the airlines, and Sir Donald Anderson, president of the United Kingdom Chamber of Shipping, said recently that " either some form of equilibrium must be established between air and sea to allow each to do what it is economically fitted to do ; or sea will have to be subsidised, or air transport will simply wipe us out." Some shipping companies are tackling the problem by acquiring interests in private airlines, but this cannot be a satisfactory solution for the industry as a whole.

Subsidies apart, the most valuable assistance that the Government could render shipping would be to review depreciation allowances. Few other industries have to replace such expensive assets so frequently as the shipping industry must do, and the difference between the prime cost of ships, upon which the Inland Revenue base depreciation allowances, and their replacement costs is now considerable. Lord Teynham, in the debate on shipping in the House of Lords on December 9, said that the replacement of a ship which cost £100,000 before the war would now cost £400,000 ; and whereas the owner would have been prudent if he retained the £100,000 which the Inland Revenue allowed him tax-free out of profits for replacement, the remaining £300,000 would have to be found out of taxed profits. This meant, in fact, that he would have to find more than double the amount, a total of £700,000 out of earnings, which was almost impossible.

The Government do not seem, however, to be impressed by the urgency of the situation ; the Earl of Selkirk said on their behalf that they recognised the need for further action if the position was to be improved, but the question of replacement should not arise for the next five years. The shipbuilding yards were full, and the only limitations were material rather than financial. Moreover, the industry as a whole had sufficient reserves to finance the immediate programme, though individual companies might be less well off.

Disappointed shipowners have not been slow to point out the dangers of this Government policy, which apparently requires that nothing shall be done until the industry is actually " on the rocks." Meanwhile, replacement costs continue to rise. The liner Orsova, launched by Vickers-Armstrongs Limited at Barrow in May, is estimated to have cost £2 millions more than her near-sister ship the Orcades, built in 1949 at a cost of about £3·5 millions. Sir John Boyd, the permanent vice-president of the Shipbuilding Employers' Federation, said in evidence before the Court of Inquiry into the industry's wages dispute, that the claim for a 15 per cent. increase would add £10 millions to the wages bill, which in 1952 amounted to £57 millions. This would mean that the price of a fairly fast Diesel-engined tanker, at present just over £1 million, would be raised by 10 per cent.

Mr. E. J. Hill, the shipbuilders' chairman of the Confederation of Shipbuilding and Engineering Unions, countered this by declaring that profits would rise in 1954 and would be even higher in 1955. In the past six years, he said, several companies had each paid dividends aggregating over 100 per cent. and they now had capital and reserves up to six times the ordinary capital. They could not go on amassing these " colossal figures and get away with it." Since most of the shipbuilding companies are of very old foundation, it would be surprising indeed if, after two wars and attendant inflations, nominal capital still bore any relation to the present value of the real capital employed. Mr. Hill's argument that productivity in shipbuilding has increased by 33 per cent. since 1948 is perhaps sounder ; it was not disputed by Sir John Boyd, who attributed it to greater mechanisation, which had reduced the efforts required by the workpeople.

RAISING PRODUCTIVITY

The progress of productivity in the past few years has been very much dependent upon the availability of steel. There should, therefore, be a further considerable advance in 1954, and all that can be done in this direction is necessary to meet the threat of foreign competition. Some Continental yards have been working two or three shifts a day, which both reduces their costs and enables them to give faster delivery. The seriousness of the situation is particularly apparent in ship-repairing ; German ship-repairers have been attracting business from Britain by low prices, and other Continental yards have won contracts through their ability to execute work, on occasion, in not much more than half the time required by British repair yards. British ship-repairers have undertaken very heavy outlays in recent years on docks and equipment capable of handling the larger and faster vessels which are now being built, but much remains to be done. While taxation continues at the present levels, and adherence to the 44-hour week does not permit new equipment to be used as intensively as it might be, the incentive to modernise further is not great.

There is still, however, considerable enterprise in British shipbuilding and ship-repairing. The first stage of the first new shipyard to be laid down in the United Kingdom for 26 years was opened at Newport, Monmouthshire, at the end of November. This comprises a dry dock capable of handling vessels up to 8,000 tons and associated production sheds : it is owned by the newly-formed Atlantic Shipbuilding Company, Limited, who have stated that the second phase of their construction programme, which includes a dry dock to take vessels up to 45,000 tons, will be completed in the course of 1954. A third dry dock will be added eventually, but the date of completion is still uncertain.

The plan to build vessels in dry docks has been claimed to be an innovation in British practice, though in fact this is not so ; Laird Brothers, Limited, at Birkenhead – now Cammell Laird and Company (Shipbuilders and Engineers), Limited – between 1869 and 1901 built nearly a score of large ships in dry dock, under cover, including six British battleships and a liner for the Hamburg-America Line. The advantages of the method are considerable. The saving in time resulting from assembling one vessel in dry dock while the next is being made ready in sub-assembly shops should be appreciable ; moreover, costs are reduced by the elimination of slip-way launchings, which require a heavy outlay on timber, etc. The company had received orders some months before the construction of the yard was begun, and two twin-screw pulp carriers of 2,975 tons deadweight for the Quebec Ontario Transportation Company are due for delivery in August or September. Mr. John G. Howard, chairman of the Atlantic Shipbuilding Company, said in November that the company

TABLE I. UNITED KINGDOM : SHIPBUILDING ANALYSIS

Year and Quarter	Commenced		Launched		Completed		Under Construction		Preparing	
	No.	Tons	No.	Tons	No.	Tons	No.	Tons	No.	Tons
1952—March	56	324,831	62	327,141	55	267,511	356	2,270,612	324	2,393,703
June	57	205,641	62	309,018	68	405,600	343	2,076,241	321	2,531,623
September	52	267,648	61	291,276	49	266,255	343	2,062,482	327	2,684,263
December	63	389,800	66	373,177	66	324,438	336	2,146,402	306	2,606,478
1953—March	51	305,343	47	227,691	64	310,821	323	2,132,903	288	2,454,894
June	61	350,323	62	399,438	65	356,788	317	2,123,565	274	2,391,281
September	47	289,233	57	323,414	47	218,967	316	2,190,329	273	2,286,174
December	55	334,451	55	366,145	57	363,687	313	2,173,709	260	2,157,830

were being pressed to accept further orders for larger vessels from overseas buyers, so completion of the works could not be delayed.

FEWER TANKERS ON ORDER

Shipbuilding prosperity in the past few years has been founded upon the large orders received for tankers. The world tanker fleet now amounts to 22 million tons gross, or about 36 million tons deadweight, an increase of 16 per cent. since December, 1951, and 3·6 million tons more than in December, 1952. The rate of expansion will be further increased in 1954, when nearly 4·3 million tons deadweight are scheduled for delivery. Thereafter, deliveries will fall off to 3·3 million tons in 1955 and 2 million tons in 1956, but altogether, nearly 11·54 million tons are due for completion by 1957.

Meanwhile, tanker freight rates have been very weak, and there is a danger that such a large expansion may result in much unused capacity in the world tanker fleet. The spot market rate for London tanker freights, which reached a peak of 154*s.* 3*d.* per ton in January, 1952, had fallen to 29*s.* 6*d.* by the autumn of 1953, and, though there has been some subsequent recovery, they are still only about 32*s.* 6*d.* per ton. The decision of the Anglo-Iranian Oil Company and Shell Tankers, Limited, not to make use of the Brokers Award system which has been used to impart some stability to the widely fluctuating rate structure in the past few years, appears to indicate that the oil companies expect the present low level of rates to continue. Nevertheless, the volume of international trade in oil has continued to expand ; in 1952, the world consumption rose by 5 per cent. and the volume of crude oil entering world trade, by 1 per cent. In 1953, world crude oil production rose by over 30 million tons (about the same as in 1952) to a record of 654 million tons. The quantity entering into world trade, moreover, must have increased more than proportionately.

If freight rates have weakened despite increases of this sort, the outlook in 1954, should the present recession of 10 per cent. in economic activity in the United States continue, is not bright. Moreover, if the Abadan refinery were to resume operations, there would be a significant shortening of supply lines, and a consequent fall in the demand for tanker tonnage. The demand for oil may increase in the later 1950's as the amount of new tanker tonnage coming off the stocks declines, and there is every chance that equilibrium will be reached by the early 1960's. Much will depend, of course, on the rate at which the older tanker tonnage is retired, but meanwhile the independent owners have little inducement to order new tonnage.

LARGE TANKERS

Some, however, appear to have sufficient faith in the future to order new ships. At the launch, from Vickers-Armstrongs yard at Walker-on-Tyne, on February 16, of the World Harmony, of 33,000 tons – the largest tanker yet to be built in the United Kingdom – Mr. Stavros Niarchos, who now operates a fleet of over a million tons, said that he was negotiating with Vickers-Armstrongs Limited for further orders, which, subject to the firm being able to quote competitive prices, should reach a successful conclusion. Mr. Niarchos has already placed orders totalling £13 millions with Vickers-Armstrongs. These include two tankers, under construction at Barrow, which exceed " by a fair margin " the size of the 45,000-ton World Glory, launched by the Bethlehem Steel Company at Quincy, Massachusetts, at the beginning of February. Another Greek owner, Mr. A. S. Onassis, has some 45,000-ton tankers on order from German and French yards ; the Tina Onassis, launched by Howaldtswerke of Hamburg in 1953, is of 45,720 tons deadweight, but even so was just beaten in size by the Phoenix, launched for National Bulk Carriers Incorporated at Kure, and having a deadweight tonnage of 45,800.

Apart from the oil companies themselves, British shipowners have shown relatively little interest in large modern tankers. Mr. J. W. Platt, the chairman of Shell Tankers, Limited, speaking at the launch of the Hadra by Smith's Dock Company, Limited, South Bank-on-Tees, on November 20, said that British independent owners now had only 10 per cent. of all the independently owned tanker tonnage in the world, and that the Shell Group had on charter about 4 million tons deadweight, of which 3·25 million tons were of non-British registry. This was a measure of the opportunities that had been open to British owners " in a very sound business." The latter are scarcely to be blamed, however, if they follow a cautious course while the present uncertainty about the future trend of freight rates persists. Orders for 10,000-ton tankers may be received from Russia, but these will require an export licence, which may be refused. The keenness of the Russians to purchase is not in doubt, for they are said to have expressed willingness to extend the delivery dates beyond the three-years period on which they are insisting for other goods. An order already placed with British shipbuilders for trawlers amounts to £16 millions.

SUBSIDISED FOREIGN BUILDING

The peak of the tanker boom has now been reached. As may be seen from Table II, taken from Lloyd's Register's *Shipbuilding Returns*, tankers accounted for 62 per cent. of British launchings in the last quarter of 1953, but only 57 per cent. of the tonnage preparing. In 1952, they represented 62 per cent. of the tonnage preparing. The fall in tanker orders placed with foreign yards has helped to intensify competition, and British shipyards will be hard-pressed to maintain their share of world tonnage. At the end of 1953, shipbuilders in the United Kingdom (see Table III, also taken from Lloyd's Register's *Shipbuilding Returns*) accounted for 35 per cent. of the world tonnage under construction, and thus maintained the same position as in 1952. Whereas, however, the amount of shipping under construction in the United Kingdom rose by only 1 per cent., there were significant increases in the totals for all other European countries with the exception of Finland and Italy.

The Germans have again regained their position as the second greatest shipbuilding nation of the world, and the Deutsche Werft of Hamburg, who launched 145,800 gross tons, had a larger output than any other single yard in the world. As in all other shipbuilding countries, orders have been falling, and the total order book at the end of 1953 was only about 1·4 million tons, compared with 2 million tons at the end of 1952. Since launchings in 1953 amounted to about 700,000 tons, German shipbuilders have only about two years' work on hand ; nevertheless, in some ways they are in a stronger position than British builders, for the German Government are giving every encouragement to shipping and shipbuilding in order to restore the merchant fleet to something approaching pre-war dimensions. Large low-interest State loans have been available, and German shipbuilders have enjoyed important tax privileges.

A loan of 50 million marks to German shipbuilders was announced at the beginning of January. This follows a grant of 60 million marks made from Mutual Security " interests " funds. Moreover, credits of 170 million marks have been granted for the building of small ships. Even so, German shipbuilders are not very happy about the outlook. Herr Theodor Schecker, the managing director of Howaldswerke, is reported to have said that " Our shipbuilding will unavoidably contract in volume if existing tax facilities cease without a simultaneous lowering of the rate of interest in the capital market."

Direct subsidies are generally avoided as a means of assisting shipbuilding industries. Even in Japan, where, despite cheap labour, costs are substantially higher than in Europe and where the tonnage under construction fell off seriously in 1953, the Government have preferred to give indirect aid. This takes the form of a reduction in the interest rate charged by the Bank of Japan on loans of foreign exchange for iron and steel manufacture, which cuts the price of steel imported from the United States by about

TABLE II. United Kingdom : Shipbuilding Analysis by Types of Vessel. (December, 1953)

Type of Vessel	Commenced		Launched		Completed		Under Construction		Preparing	
	No.	Tons	No.	Tons	No.	Tons	No.	Tons	No.	Tons
Passenger / Passenger and cargo	2	27,800	1	7,700	4	52,496	16	258,000	10	48,980
Cargo liner	18	101,980	15	101,200	8	63,492	80	523,227	84	648,550
Cargo tramp	3	17,950	3	13,750	5	33,764	30	163,310	27	171,455
Oil tanker	16	176,946	23	230,794	22	200,589	98	1,151,404	93	1,245,010
Collier	1	3,400	2	6,760	1	1,779	8	22,920	7	18,360
Coaster	2	1,500	3	3,097	3	2,628	20	21,196	8	10,990
Miscellaneous	13	4,875	8	2,844	14	8,939	61	33,652	31	14,485

TABLE III. World Shipbuilding : Gross Tonnage under Construction

	December, 1952				December, 1953			
	For Home Owners		Total		For Home Owners		Total	
	No.	Tons	No.	Tons	No.	Tons	No.	Tons
United Kingdom	240	1,474,559	336	2,146,402	223	1,568,828	313	2,173,709
Other British Commonwealth countries	30	149,591	36	168,991	38	177,875	39	179,577
Belgium	10	36,600	23	120,700	9	55,939	26	142,459
Denmark	19	82,698	27	139,673	25	126,700	29	143,880
Finland	3	4,773	23	29,630	—	—	25	36,946
France	48	329,492	53	394,692	38	304,612	48	423,081
Germany	116	304,306	158	514,729	88	287,253	140	633,904
Italy	35	340,883	54	367,653	38	347,834	42	352,404
Japan	49	297,295	67	567,095	71	287,255	79	381,807
Netherlands	61	159,044	138	375,869	72	171,420	141	490,989
Norway	43	152,874	43	152,874	49	175,935	49	175,935
Sweden	31	195,230	53	348,075	28	164,968	56	408,748
United States of America	66	539,858	75	679,815	42	434,177	49	555,782
Other countries	91	107,192	93	112,387	100	195,655	100	195,655
Total	842	4,174,395	1,179	6,118,585	821	4,298,451	1,136	6,294,876

£9 10s. per ton ; a reduction in the interest rate on loans to shipbuilders by the Development Bank and commercial banks to 5 per cent. from anything up to 11 per cent.; and a system of tax reliefs. As a result, shipbuilding costs are expected to be cut by about 11 per cent., but even so the price of Japanese freighters will probably be 3 or 4 per cent. above the international level. There is, of course, no guarantee that Japanese shipbuilders, anxious to keep their yards employed, will accept foreign orders at uneconomical prices, and their ability to give quick delivery may, in any case, bring them business. Home orders should keep about half of their capacity fully occupied, for the Government shipbuilding programme provides for an output of 300,000 gross tons per annum, of which about 70,000 tons will be tankers. One of the Japanese yards, the former naval establishment at Kure, leased by National Bulk Carriers Incorporated, has been enjoying a high level of activity ; three tankers of 32,000 tons deadweight were launched as well as the Phoenix, previously mentioned ; the keel was laid in May, and she was launched in October. One of the three ore carriers of 60,000 tons deadweight, which were subsequently laid down, has now been launched and is claimed to be the largest dry-cargo vessel in the world.

ATOMIC PROPULSION

Direct subsidies to the shipbuilding industry in the United States have been discontinued, though shipowners are still receiving Government grants. Orders have fallen off completely. All the major civil shipbuilding contracts will be completed in the current year, and there are no definite prospects of new orders. This follows a record peace-time output in 1953 of 530,000 tons gross, compared with 467,545 tons in 1952. The Bethlehem Steel Company's Shipbuilding Division launched a total of 247,500 tons in major ships from their three yards ; one of these, Sparrow's Point, achieved 125,093 tons. The experience of the United States Government in subsidising merchant shipbuilding has not been encouraging. Since the outbreak of the Korean war, 21 Mariner-class fast freighters, of 12,900 tons and capable of 22 knots, have been built ; but, though these were offered to private operators at prices well below cost, only one company, the Pacific Far East Line, who recently obtained an operating subsidy, have come forward as prospective purchasers. United States shipbuilders are now looking primarily to naval orders to keep them employed. The Government's projected programme is for a third giant aircraft carrier, estimated to cost 210 million dols., 14 destroyers, minesweepers and similar craft, and 150 landing craft.

One of the achievements of United States naval construction is, without doubt, one of the most significant shipbuilding developments of recent years. The atomic-powered submarine Nautilus, which was launched at Groton, Connecticut, on January 21, will be able to stay submerged for more than 50 days, and is said to be able to outrun, either submerged or on the surface, most of the world's ships. It has several disadvantages, however, not the least being the high cost of about £18 millions. The atomic plant is expensive, and, with a displacement of more than 3,000 tons, the vessel may be difficult to manœuvre, offering a substantial target for detecting devices. Nevertheless, the Nautilus heralds a revolution in naval strategy as well as in ship propulsion. A second atomic submarine, the Sea Wolf, is already under construction at Groton.

In the British naval programme the emphasis is on anti-submarine and mine-sweeping craft. Expenditure on shipbuilding repairs, etc., will be increased this year by £21·7 million to £177·9 million. This includes completion of three aircraft carriers and work on a fourth. Outlay on new vessels is actually reduced. Research in shipbuilding and marine engineering is as active in the United Kingdom as in the United States. To take an example, the development of marine gas-turbine production is more advanced in the United Kingdom than elsewhere. Such notable recent launchings as the Orsova, Arcadia, and Saxonia bear witness to the continuing high quality of British ships. The problem of high costs requires urgent attention, but, despite increasing competition, British shipbuilders should hold their own. They have the means and ability to maintain the British merchant fleet as the most efficient operating unit in the world; it is only to be hoped that sufficient orders will be forthcoming before it is too late.

ACCURACY OF TIME-STUDY RATING

SEEKING A MEASURE OF PRODUCTIVITY

By C. J. Anson

Time-study rating is subjective and serious errors can occur in time standards if the ratings are erroneous. A team, the Work Measurement Research Unit, was established in the University of Birmingham to investigate the quality of time-study rating. It was headed by Professor T. U. Matthew, the other members being Mr. P. B. R. Gibson, Mr. D. J. Desmond and the author. The Research Unit first made a pilot survey over a limited number of firms to obtain experience in the proposed method of measuring the quality of time-study rating. This was followed by a large-scale survey covering the United Kingdom of time-study engineers' rating ability. In this later survey about 750 engineers took part, but the results of this work have so far remained unpublished. This article deals exclusively with the pilot survey.

PROCEDURE IN THE PILOT SURVEY

The pilot survey was made at about the same time as a similar survey conducted in the United States by the American Society for the Advancement of Management. The films used were copies of the film prepared for the S.A.M. pilot survey by Mr. H. J. Lynch and the experimental procedure was a modification of that developed by the same Society.

The rating film was shown to 11 different groups of time-study engineers. These engineers had been chosen by their own firm, each firm being asked to select only time-study engineers who were able to rate to the firm's standard. The same procedure was adopted at each showing. The three operations contained in the first reel were fully described with the aid of diagrams and photographs. The reel was then projected and rated. The remaining three operations contained in a second reel were then described and rated in an identical manner.

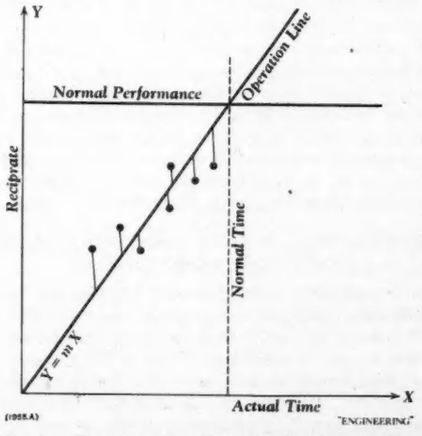


Fig. 1 The operation line, showing the relationship between "reciprates" and the actual time taken to perform a given task. By definition, the operation line is constrained to pass through the origin.

The basis of all methods of analysing time studies is that the rating is inversely proportional to the actual time taken. Mr. Desmond* has designated the reciprocal of the rating multiplied by a constant, the latter so chosen that normal performance is represented by the figure 100 in all scales, as the "reciprate." Consequently the basis of the analysis may be restated in the form reciprates are directly proportional to the actual time taken. Thus, when reciprates are plotted against the actual time, the plotted points should lie on a straight line passing through the origin. In practice the points were found to be scattered about this line, which was taken to be the best straight line drawn through the plots and constrained to pass through the origin; this line is called the operation line and is shown in Fig. 1. The normal time for the study was estimated by the time on the operation line corresponding to the reciprate of the normal performance.

The degree of scatter about the estimated operation line was used to measure the ability of an observer to rate consistently on the assumption that reciprates are proportional to the actual time taken. The scatter of the plotted points about the operation line $Y = mX$ was measured by the variance of m, var(m). The coefficient of variation of m, expressed as a percentage, namely, $\frac{100\sqrt{\text{var}(m)}}{m}$, was chosen as a measure of the inconsistency of rating and called study inconsistency.

Most time-study engineers under-estimate changes in production rate from a central value. As a result, the plotted points were scattered about a line, the study line, which did not pass through the origin, as shown in Fig. 2, over-page. This characteristic, called flatness, may be estimated quantitatively in a rated study. Percentage flatness was defined from Fig. 2 as $100\ \frac{OP}{OQ}$ where OQ is the reciprate of the point of intersection of the study and operation lines, and OP is the reciprate at the point of intersection of the study line with the reciprate axis. When the operation line and the study line coincide, the flatness is zero; when the study line is horizontal, the study is 100 per cent. flat. To consider the effect of flatness, suppose that a study is 30 per cent. flat, and that an observer can assess an 80 performance – that is, on the 60/80 rating scale, a rate 33 per cent. above normal – correctly, thus determining a normal time, t. If the task were studied at a 60 performance, the resulting normal time would be 8 per cent. loose. If the task were studied at a 100 performance, the resulting normal time would be 7 per cent. tight.

* "Work Measurement Research," by D. J. Desmond. ENGINEERING, vol. 170, page 310 (1950).

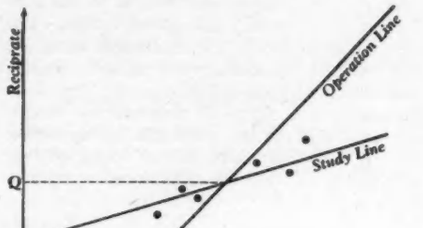


Fig. 2 The study line, and its relationship to the operation line. The study line is not constrained to pass through the origin and the difference in slope between the two lines is a measure of the "flatness" of the study.

The precision with which the operation line was estimated, measured by var(m), was used as a criterion for rejecting studies considered to be rated less consistently than those of the remaining members of the group. Both the inconsistency and the normal time of each rejected study were omitted when calculating the average normal time of the group for each operation.

In addition, the distribution of normal times within a group was checked for each operation. Times differing from the group average by an amount which should not have occurred on more than 1 in 1,000 occasions, were omitted from the calculation of the average normal time.

RESULTS OF THE PILOT SURVEY

The normal times established by the engineers who were not rejected by either of the tests just described were as follow :—

Operation	No. of Engineers	Description of Operation	Normal Time (secs.)	95 per cent. Confidence Limits
A	164	Deal four cards ..	2·41	±·04
B	165	Transport two marbles	1·52	±·03
C	164	Climb 10 steps ..	6·01	±·10
D	181	Drill one spindle ..	5·94	±·06
E	182	Pack one set gaskets	26·8	±·40
F	177	Stack one carton ..	3·04	±·05

The precision with which a normal time was established depended on the operation studied but not on the group studying it. Because of his inconsistency, once in 20 rated studies of 20 cycles, an individual engineer's normal time would differ from the normal time which he himself would establish from a very large number of cycles by the following percentages.

Operations	Inconsistency per cent.
C and F	5
A and E	6
B and D	7

Due to flatness of rating, low performances were over-rated and high performances under-rated. If it is assumed that an observer can rate an 80 performance correctly, then the average errors in normal times established at 60 and 100 performances were as follow.

Operation	60 performance	100 performance
	Looseness, per cent.	Tightness, per cent.
A—Deal cards ..	4	4
B—Transport marbles	7	6
C—Climb steps ..	4	4
D—Drill spindle ..	10	8½
E—Pack gaskets ..	15½	12
F—Stack carton ..	8	7

It is clear that the normal time established was influenced by the average rate at which the operator was working. A similar result, found by D. J. Desmond* for studies made on the shop floor, provided further evidence of the existence of flatness of rating, showing that it was not only attributable to the rating of films.

DIFFERENCES BETWEEN ENGINEERS WITHIN A GROUP

The results of the pilot survey show that the method of time study cannot be credited with the accuracy which has been claimed by many authorities.

Especially noticeable was the variation in concept of normal performance between different engineers within a group, estimates of which are given in the accompanying table for each group, for each operation. Within each group, 5 per cent. of the accepted engineers gave normal times which differed from the group average by more than the percentage tabulated.

Variation between engineers within a group

Group	Operation					
	A	B	C	D	E	F
1	22·8	13·3	23·7	20·8	14·7	21·9
2	50·0	49·3	43·4	42·0	40·4	41·6
3	18·4	19·7	25·3	33·9	34·5	31·2
4	20·0	19·6	21·8	24·0	17·0	14·6
5	24·7	17·0	16·6	21·1	14·9	19·3
6	21·7	22·2	23·3	17·4	20·0	29·0
7	18·7	11·6	14·1	7·7	14·9	19·3
8	13·6	18·3	25·3	17·6	22·6	29·2
9	22·1	24·8	17·3	26·6	21·5	21·9
10	40·0	48·5	33·8	27·1	29·6	29·6
11	18·9	15·2	21·9	28·1	17·2	26·2

The general features of this table are summarised in the following statements. Due to differences in concepts of normal performance between engineers within a group, a single study made by one engineer would be expected to differ from the group average by as much as 20 per cent. once in 20 rated studies. In Group 7 the differences between the engineers' concepts of normal were not so large, and here an engineer would be expected to differ from the group average by not more than 12 per cent. once in 20 rated studies. The engineers in this group were all trained by the present chief time-study engineer. In Groups 2 and 10 (two groups which do not usually rate time studies), the differences between the engineers were larger, and in these two groups an engineer would be expected to differ from the group average by as much as 34 per cent. once in 20 rated studies.

Contrary to general belief, the level of rating was independent of the group considered, the main source of variation in normal times being differences between engineers within each group. In the later survey, it was found that there were differences from group to group which could not be explained by differences within the groups. This later and larger survey may well be correct, and it is difficult to reconcile the results. It is possible that there were differences between the groups of the pilot survey even though the statistical analysis did not confirm their existence.

EXPERIENCE, PRACTICE AND ACCURACY OF INDIVIDUAL ENGINEERS

The engineers taking part in the survey were classified into three groups, according to whether they had spent (i) up to 25 per cent., (ii) over 25 and up to 75 per cent., (iii) over 75 per cent. of the previous six months on time study involving rating. They were also classified into four groups, according to their number of years of experience, (i) up to two years, (ii) over two and up to four years, (iii) over four and up to six years, (iv) over six years.

* *Loc cit.*

From each of the resulting 12 groupings, three engineers were chosen at random, and the variations in the normal times and in the measures of inconsistency and flatness of observations made by these 36 engineers were examined in detail. In order to consider all the effects of training and experience, this selection was made from all the participating engineers, including those rejected by the tests of consistency and level.

In investigating the effect of experience on the level of rating, differences between operations were eliminated by expressing each individual normal time as a percentage of the average normal time for the particular operation studied.

As was to be expected the inconsistency of rating was affected by the intensity of recent practice in time study, being least on the group with the most recent practice. This suggests that check time studies made by supervisors will probably determine normal times less precisely than the original normal times were determined by the engineers being checked, since these latter engineers are engaged primarily on time-study work involving rating.

The length of experience did not appear to influence the inconsistency, but the analysis suggested that it affected flatness. There was, however, no general trend of decrease or increase of flatness as experience increased, so that the fact that flatness was least for the group which had between four and six years' experience must be attributed to other characteristics of the engineers forming the group rather than to their length of experience. The same engineers also rated more tightly than the engineers in the other groups, but again there was no general trend of increased normal times with increased experience.

The analysis confirmed that the ability of an engineer to judge proportionate changes of speed, and also to recognise the same speed when it occurred again, depended on the nature of the operation being studied. Both the study inconsistency and the flatness differed from operation to operation, though not in an identical manner.

It was considered that the difficulty which the engineers experienced in rating the respective operations might be a reason for the variation in inconsistency and flatness from operation to operation. At the foot of the rating form on which they recorded their observations they were asked to note the difficulty they experienced in rating each operation. A graduated scale was provided, on which points corresponding to " very easy," " easy," " moderate," " difficult " and " very difficult " were indicated.

There was no association between the subjective estimates of difficulty and the inconsistency, and only in operation D was there a possible association between the subjective estimates and the deviations of the normal times from the average normal time. However, there was a marked correlation with flatness on operations A and D, and also when the six operations were considered as a whole.

In effect, the time-study engineer was able to rate the operation which he considered difficult to rate as precisely as any other operation, but he rated high ratings much lower and low ratings much higher than usual. The tendency towards the conventional rating, it seems, is greatest when the operation is considered to be the most difficult to rate.

IRREGULARITIES IN THE RATING FILM

Although flatness is an important cause of inconsistency it was considered that the irregularities occurring in the rating films were also a possible cause of inconsistent rating. The effects of these irregularities, of flatness, of differences in level from one engineer to another, and of

other rating errors have been assessed by an extension of the reciprate method.

The detailed results of the analysis have been summarised in Fig. 3, which shows the residual range of ratings when each significant cause of variation has been removed. It is based on the approximation that the total range of the ratings made by the 186 engineers on any one scene was 50 in terms of the 60/80 rating scale.

The analysis suggested that the effects of both irregularities in the film and also of other inherent inaccuracies in the rating process were as described in the following paragraphs.

The change in method which occurred in scene E-5 was so small that it could easily have been overlooked. Nevertheless it affected the concept of normal performance considerably. The existence of the change of method in operation E probably accounted for the high variation in the ratings within each study, which, on this operation alone, was sufficient to explain all the apparent differences both between engineers within a group and also between the groups themselves. It would seem that such variation in method could very easily arise in studies on the shop floor.

Scene B-12 was of five seconds duration, compared with an average of 16 seconds for the remaining scenes. It was rated more inconsistently than the other scenes, but the concept of normal performance was apparently unchanged by the fact that this scene was shorter than the others. It was the last of the 12 scenes showing operation B in which the task, a simple one, consisted of picking up marbles and placing them in a box. It must therefore be assumed that the task was fully understood and the excessive variation must be evidence that more than five seconds is needed to assimilate the rate of working. The American Society for the Advancement of Management claims that, from a similar survey carried out in the United States, the distance and angle from which the scene was shot affected the concept of normal performance. There was no evidence that this was the case in the pilot survey.

The ratings of the first scenes of operations A and D were as consistent with the method of analysis as those of the remaining scenes. It is therefore probable that the engineers were briefed well enough before each showing to enable them to make a reasoned rating on the first scene of each operation. Moreover, the rating of scene A-1 suggests that the rating of films was not such a departure from reality as to cause difficulty at the first attempt.

The method of analysis enabled both the effects of differences in level from one engineer to another and also the effects of flatness to be estimated and removed. It confirmed that these two sources of error in time-study rating were major causes of the variation between and within studies, respectively.

As well as being over-rated due to flatness, low rates of working were seen to be more difficult to rate. A contributory cause of the variation in the reciprates estimated for the low rates of working may be the rating scale. An error of five at a 40 performance results in an error of about 12 per cent. in the normalised time, but an error of five at an 80 performance only causes an error of about 6 per cent. As engineers usually rate in steps of five, the rounding off of, say, 37 to either 35 or 40 would introduce greater variation than the rounding off of 77 to either 75 or 80.

IMPROVEMENT OF TIME-STUDY RATING

Since the subjective method of rating is widely applied in present-day time study, it would be well to consider the steps which can be taken to improve the accuracy of its application.

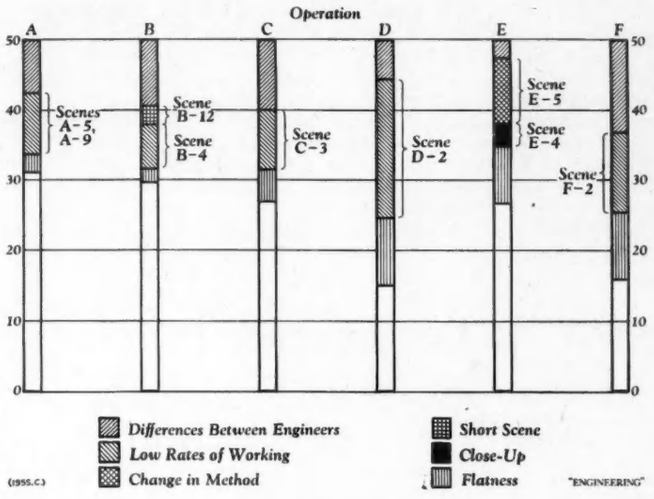


Fig. 3 Significant causes of variation in ratings and the approximate range of error on one observation.

Before any time study is made the job should be accurately specified and the method employed accurately defined. In the pilot survey, each operation was specified in detail, and the engineers taking part were able to question any points on which they were not clear. With the exception of operation E (packing gaskets) the operations were very simple and easy to understand. Consequently, the variation arising in the normal times due to inadequate job specification was most probably negligible. This is confirmed by the detailed analysis of the films, which showed that the engineers were able to make a reasoned rating on the first scenes of the two operations examined.

Only one change of method was made during the experiment and this occurred in operation E. Although this change was so small as to be almost unnoticeable, it altered the concept of normal performance from an average of 28·2 seconds to an average of 22·6 seconds. This shows the need for the well-established procedure whereby new standards are determined whenever the method is changed, and also the care with which a method must be defined. As differences in method must be expected in all jobs, a precise definition of the method is clearly necessary.

The amount of the variation within each study could be reduced considerably if the errors due to flatness of rating were eliminated. Either the current method of analysis may be accepted, in which case every effort should be made to reduce flatness, or flatness may be accepted as a characteristic of rating and the method of analysis adjusted to allow for it. The author considers that flatness is a rating error and that an attempt should be made to remove it.

Flatness was greatest on the operations which the engineers considered most difficult to rate, although there is no evidence that these operations were less precisely rated than the others. It would appear, therefore, that an engineer tends to choose the conventional rating for reasons similar to those which make an individual choose the middle value in any investigation. Moreover, a knowledge that flatness exists leads to a reduction in its magnitude. This has also been noted at a Summer School prior to the pilot survey, when a group of observers rated the films on two separate occasions.

Two sources of inconsistent rating found in the survey may not occur very often in practice. The first was attributed to the inability of engineers to rate low rates of working as precisely as other rates of working. The second occurred in operation B (transporting marbles) in which the final scene only lasted five seconds. Both these causes of variation emphasise the necessity to rate operators working at about an 80 performance and to divide studies into elements of from 10 to 30 seconds.

The experiment confirmed that engineers who spent 75 per cent. or more of their time on rated studies were able to rate more consistently than engineers who spent a lower percentage of their time on rating. It is probable, therefore, that inconsistency could be reduced by training and by refresher courses in which engineers could analyse studies and determine measures of inconsistency and flatness. The causes of variation within studies, especially flatness, can be determined by plotting the reciprate against time on specially prepared reciprate graph paper for routine studies. Knowledge of the existence and extent of such variation is the first step to its removal.

In the group in which the differences between the normal times established by individual engineers were the least, the engineers had all been trained to rate by the same person. The differences were greatest in the groups unfamiliar with the rating process. It is suggested, therefore, that some programme of co-ordination should be attempted within each firm to reduce this source of variation, which was responsible for a major part of the differences in the normal times established. A temporary expedient to reduce variation in normal times due to the differences in average level from one engineer to another would be for several engineers to take short studies on an operation rather than for one engineer to take a long study.

In addition to differences occurring in the average concept of normal performance from individual to individual within a group, the engineers did not agree on the relative amounts of work in each operation. The variation in normal times arising because of this may be reduced by dividing each operation into a sufficient number of elements, and rating each element separately.

If engineers in a group were to rate film or shop operations and compare the results of such studies, it is probable that individual engineers' concepts of normal performance would be brought closer to the average concept of the group, and also that there would be closer agreement on the relative amounts of work seen in particular operations.

Although the greatest immediate improvements in time-study practice appear likely to result from improvement within the groups, it is desirable to reduce any existing differences from group to group to a minimum. A universal

unit for measuring productivity is needed, and if the work unit is to become that unit of productivity, a universal standard of normal performance must be established.

A standard film of a man of average stature, walking unladen in still air at a speed of 3 m.p.h., might be used to define a standard normal performance. Copies of this film, together with a set of normal performances on a wide variety of operations, could be used in group rating sessions to reduce the variation between the groups. It might be preferable to establish the secondary standards by a number of different performance rates, and the films of the six operations of the pilot survey, and the films of the nine operations of the later survey are very suitable for this purpose.

The use of such films would enable a more uniform concept of normal performance to be established from group to group and even from nation to nation. The ideal must be to make the concept of "normal" sufficiently consistent with the primary standard that a practical unit of productivity can be developed.

UTILISING SCOTLAND'S PEAT

DEVELOPMENT OF PEAT-BURNING TURBINES TO CONTINUE

Peat, a fuel which for many years has smouldered in the grates of crofters' cottages in Scotland and Ireland, continues to grow in importance in relation to the national fuel resources. It is now estimated that in Scotland alone there are 600 million tons of solids, equivalent to 500 million tons of coal. Full development of the peat land, it is believed, would provide employment for 20,000 people for 100 years. After peat has been cut the upper layers of the ground can be relaid or other methods adopted to produce arable land.

Though peat has been used mainly as a fuel for boilers and experimental gas turbines it has a number of other uses. It yields from 3 to 17 per cent. of ester wax and it is used for gas purification in a substance known as Granox. If air-dried peat containing 25 to 30 per cent. moisture were carbonised it would yield about 25 to 30 per cent. coke or char, 5 to 10 per cent. tar, 15 to 40 per cent. gas, and 30 to 50 per cent. aqueous liquid. Peat coke has a carbon content of 85 to 90 per cent. and could be used in the metallurgical industry; the gas has a calorific value of about 350 B.Th.U. per cubic foot. Distillation of the tar gives 70 to 80 per cent. oil and leaves a residue of 20 to 30 per cent. pitch. The oil contains hydro-carbon oil, paraffin wax, and acidic material. The aqueous liquor contains ammonia, methyl alcohol, acetone, acetic acid and tar acids. Peat has also been used as a raw material for the Fischer-Tropsch process and has been mixed with concrete to form a building material. Besides this it is commonly used in Scotland in agriculture and horticulture, and is used by the medical profession as an absorbent.

Other facts about this fuel are given in a report* issued on February 9 by the Scottish Peat Committee, which has held meetings, since it was appointed in 1949 by Mr. Arthur Woodburn the then Secretary of State for Scotland, under the chairmanship of Sir Edward Appleton.

PEAT-FIRED TURBINES

The report states that Britain has taken the lead in developing solid-fuel gas turbines and that the experiments are being watched with interest by a number of countries. It is estimated that a small peat-burning closed-cycle gas turbine of 2,000 kW might produce power at a cost comparable with a small Diesel station of similar output. Once a large peat-fired plant has been produced it is thought that large overall economies could be effected, and that such a plant would produce power at a price comparable with that of large coal-fired steam-operated power stations.

* *Report of the Scottish Peat Committee.* Scottish Home Department. H. M. Stationery Office (5*s.* net).

The two gas turbines which have been used in the investigations so far carried out are a 750-kW open-cycle set ordered from Ruston and Hornsby, Limited, in 1949 by the Ministry of Fuel and Power, and a closed-cycle machine on which John Brown and Company, Limited, have carried out development tests. Initially the latter involved the design and manufacture of a combustion chamber, flue-gas drying system and peat-grinding and handling equipment. This plant began a series of tests in 1950, and after some modification satisfactory combustion was obtained. The flue gases from the chamber were used to dry the peat from the moisture content of 50 to 55 per cent. to 30 per cent., which made it acceptable for combustion. This system was coupled to a Pametrada 500-h.p. gas turbine. In 1952 an endurance run of 1,000 hours was completed. At present further attempts are being made to recover an additional quantity of waste heat to dry the peat from a 75 per cent. moisture content, and a drum type of drier has been ordered for experimental work.

The open-cycle gas turbine, which was ordered in 1949, is an adaptation of the Ruston and Hornsby oil-fired industrial gas turbine and makes use of a peatgrinding, pressurising and entrainment plant. Tests began on the complete unit in 1952. After short runs a feed pump was installed to enable peat to be fed continuously at the combustion-chamber operating pressure. Prolonged runs were commenced in March, 1953, and satisfactory performance has so far been obtained.

From the thermodynamic point of view, it is stated, there is little to choose between the open and closed cycles, and further development of the two units would be greatly facilitated by the introduction of an economic process for removal of water from peat.

It has been recommended by the Committee that the 750-kW gas turbine together with a peat de-watering press ordered by the Ministry of Fuel and Power should be installed at Altnabreac, Caithness, where it has been suggested an experimental peat-burning power station, incorporating a 2,000-kW turbine, should be set up. Ultimately the station would be transferred to the North of Scotland Hydro-Electric Board, who have offered to pay the running costs at that stage. Since the report was drafted the Board have also offered to pay part of the capital cost of the closed-cycle plant. The British Electricity Authority are also contributing to the cost of the open-cycle plant.

PRODUCTION OF PEAT

Considerable attention has been given to the farming of peat and a number of different processes have been tried. The early method of hand cutting and drying by stacking in the open is well known. The use of mechanical cutters, maserators and spreaders, which has been tried, has shown that smaller and probably more efficient machines and methods are required if the price of the peat fuel is to be kept below that of coal.

In Denmark and Ireland peat is washed from the bogs by high-powered water jets and then pumped to drying fields where, after a time, it is cut into blocks. Peat prepared in this way is known as hydro-peat. The committee do not, however, consider that this method is worthy of adoption unless a cheap method of removing the water from the peat can be discovered.

At present, milled peat, which is produced by taking a horizontal cut $\frac{1}{2}$ in. deep over a large area, appears to be one of the most satisfactory and economical form of this fuel. When the cut has been taken the peat is left to dry *in situ* for a day or two and is occasionally upset by harrowing. This method was developed by Peco, Limited, at Loch Moss, Scotland, and is now used in Ireland, Denmark, Sweden and Normandy. All the moss operations have been mechanised and the peat is not touched from the time it is cut until it reaches the briquetting ptant. The briquettes are said to be the best fuel yet made from peat and have a calorific value of 8,000 B.Th.U. per pound. Bad weather in Scotland diminishes the number of harvests of milled peat, and it is estimated that only 18 to 20 harvests a season could be obtained. The cost of milled peat at 1952 prices was estimated at 23*s.* 6*d.* a ton; this is roughly competitive with the coal delivered to power stations in the north of Scotland, the difference being 3·7 pence against 3·6 pence per therm for coal.

The report recommends, finally, that surveys of Scotland's peat deposits should continue. The Committee do not consider that a Peat Board should be set up at present.

* * *

OIL HANDLING INSTALLATION AT EASTHAM

Work on the oil handling installation, or tank-farm, at Eastham, near the new Queen Elizabeth II Dock at the western end of the Manchester Ship Canal, was started in 1952 on an 18-acre site and the installation came into use when the dock, which was described in our issue of January 29, was opened on January 19.

The installation, built for the Shell Petroleum Company, Limited, at a cost of approximately £1 million, provides reception facilities for crude oil discharged at the new dock and enables departing tankers to be back-loaded and bunkered. Two 20-in. pipelines connect the dock-side discharging points to six reception tanks, each line being capable of taking 2,000 tons of crude oil an hour.

From the six reception tanks, oil is pumped through a 16-in. pipeline to the new Stanlow refinery five miles distant and, under normal working conditions, pumping is done by two of three electrically-driven high-pressure pumps made by Mather and Platt, Limited, Manchester; working in parallel, two pumps deliver 960 tons an hour at a pressure of 348 lb. per square inch. Also provided is an alternative set of low-pressure pumps, also made by Mather and Platt, Limited, which can move 600 tons of crude oil an hour at a pressure of 156 lb. per square inch. By connecting both sets of pumps in series, the rate of flow may be increased to 1,200 tons an hour at a pressure of 480 lb. per square inch.

THE EFFECTIVE UTILISATION OF MATERIAL*

PERFORMANCE, WEIGHT AND COSTS

By Frank Nixon†

"Material utilisation" is a term generally understood by engineers to mean that proportion of material bought for a purpose, in the form of ingot, bar, forging, sheet, strip, tube, wire, and so on, which is converted into a finished product. The conversion of ingot into usable forms such as bar or sheet involves a mill loss of 40 to 50 per cent. With static castings, the yield from the metal melted may vary between 45 per cent. and 65 per cent. In drawing bar into wire-rod there will have been a loss of about 5 per cent., and a further loss of 5 per cent. in drawing the rod down to wire.

Taking as the measure of success the overall value of the product to the customer, we can examine the factors which, to a greater or lesser degree depending upon the application, affect the effective utilisation of material. None of these factors can stand alone; by far the most important one is design. Within the limits laid down by the design of a product for its purpose, the other departments of an organisation play a vital part in its success. Thus the development engineer and the production engineer, whether they be concerned with tooling and planning or manufacture, and the research worker can, to a greater or lesser extent depending upon the product and its field of application, increase its reliability and specific performance while reducing its cost and finding means of extending its life by development, repair and reclamation. The sales department ensures that the right product has been chosen for manufacture, and the service department helps it to succeed by ensuring that it continues to function to the satisfaction of the customer.

Fundamental or basic design, and detail design each have a considerable influence upon the effectiveness of the material utilisation. Nevertheless, it is as well to point out that a brilliant design can fail if the production engineers do not live up to it, just as many a mediocre design has been made a success by the efforts of the production engineer.

GAS TURBINES

We have from long usage become accustomed to seeing large relatively slow-moving steam-engines and Diesel engines applied to stationary and marine work, and only in the air and on the roads have we seen anything approaching an effort to put the material of prime movers to really effective use. And now in these fields the gas turbine is providing a striking example of the influence of fundamental design. Whether it is applied to air, marine, or stationary duties, this type of engine produces power for from one-third to one-seventh the weight of the lightest equivalent power unit.

Thus in the stationary field the Ruston and Hornsby Mark T.A. gas-turbine engine has a continuous rating of 1,200 b.h.p. for a basic weight of 12,300 lb. which is stated to be one-third the weight of the best equivalent engine. In addition, there are other great savings in the installation, since no heavy foundation is required, and no cooling system, no water softeners, no coal bunkers, and no ash-disposal plant.

In the marine field, the Rolls-Royce Marine gas turbine RM. 60 produces 5,400 b.h.p. for 29,000 lb. weight. As installed in the vessel Grey Goose, two of these engines displaced two 4,000 b.h.p. steam turbines which were the lightest steam power units of their type ever produced, but which weighed twice as much. In addition the RM. 60 engines require 25 per cent. less space, and give 30 per cent. lower specific fuel consumption.

The Avon Mk. I engine has a static sea-level thrust rating of 6,500 to 7,500 lb., depending upon the model. It weighs, complete with its jet pipe, 2,710 lb. and it is used to power the Comet II aircraft. To propel this aircraft through the air at its continuous cruising speed of 500 m.p.h. at 40,000 feet, requires about 10,000 h.p., or 2,500 h.p. from each engine. The highly supercharged Merlin 724 piston engine weighs dry, 2,400 lb., but with radiator and cooling medium, oil cooler, propeller and exhaust system, etc., i.e., as a "going engine," about 3,600 lb. At 40,000 ft. it could deliver 450 h.p., or effectively, assuming 80 per cent. propeller efficiency, 360 h.p. Admittedly the engine was not designed to operate at this altitude but it is obvious that the Avon engine is making far better use of its material than are prime moves in other fields.

At the other end of the horse-power scale, we have the small French gas turbines, the Blackburn-Turbomeca Artouste I and II, giving continuous powers of 226 b.h.p. and 325 b.h.p. for 183 and 200 lb. weight respectively.

If the normally accepted solutions are examined critically, it is difficult to see why the typical stationary and marine Diesel engines are such huge heavy monsters. The reason is most probably that given by Sir Harry Ricardo,* "One cannot escape the suspicion that the use of very large Diesel engines at sea is due, as Sir Alfred Ewing suggested recently, 'rather to the taste and fancy of some dominating personality than to a careful weighing of arguments such as appeal to engineers'."

In 1931 and again in 1933† Sir Harry strongly pressed the advantages of using a multiplicity of small high-speed Diesel engines instead of the large ones which were and are still the prevailing fashion. He showed that the weight per horse-power fell appreciably as engine speed rose and engine size was reduced, and though the cost per ton of the high-speed engine might be treble that of the slower engine, the resulting cost per horse-power of the high-speed engine was only about one-quarter that of the slow one.

DETAIL DESIGN

Within the bounds laid down by the basic design, the designer is able to exert a considerable influence upon the product. He will give due weight to a number of considerations having an important bearing upon the way in which the material is used. These include some or all of the following, depending upon the type of thing under consideration: (*a*) purpose and function of product, (*b*) performance, (*c*) cost, (*d*) weight, (*e*) appearance, (*f*) ultimate life, (*g*) running cost, (*h*) overhaul cost, (*i*) scale of production, (*j*) availability of desirable materials, (*k*) manufacturing facilities available. The relative importance of these factors will vary enormously with the type of product, and with the rate and scale of production anticipated for it.

Mention has already been made of the advantages of small light oil engines. The aircraft engine provides an even more striking example. In order to obtain the highest performance with minimum weight the aircraft engine designer works his engine at the highest temperatures feasible with available materials and he works those materials at the highest possible stresses. This means that expensive special alloys are specified where necessary, and there is no hesitation in calling for what in other fields might seem to be an excessive amount of machining. Yet the net result is that the prime cost, per brake horse-power at continuous rating, is appreciably lower for the aircraft engine of the type under review than for any other type of engine in its power class. This is due partly to the quantities produced, but largely to the fact that the increased cost of material and of the greater amount of machining are more than compensated by the increased amount of work done by the material.

COST PER HORSE-POWER

Interesting light is thrown on this by a comparison of the Merlin 724 and the Avon Mark I engines. In the bare engines, the overall material utilisation figures are about the same, but the average cost per pound of the raw material used for the Avon is roughly double that of the Merlin. The manufacturing man-hours per pound are much higher in the case of the Avon, due to the difficult shapes and still more to the difficult materials employed. Yet the cost per continuous horse-power of the Avon Mark I even at its present early stage of development, is roughly half that of the Merlin under equivalent conditions, and this ignores the additional cost of the airscrew, radiators, cowling, etc., which are necessary to convert the Merlin into a similar "going engine."

With all this, the aircraft-engine designer has to keep a careful eye upon the strategic content of his alloys, which may contain high percentages of nickel, chromium, molybdenum, cobalt, etc. It is interesting to note here that in addition to their being technically well ahead, British aircraft gas turbines employ far less of the "strategic" alloys than do the American engines, and this is another example of effective utilisation of material.

An example of this is seen in the case of the Nene turbine disc, Fig. 1. This was made originally from a forging weighing 148 lb., in a strategic alloy. By applying air cooling to the

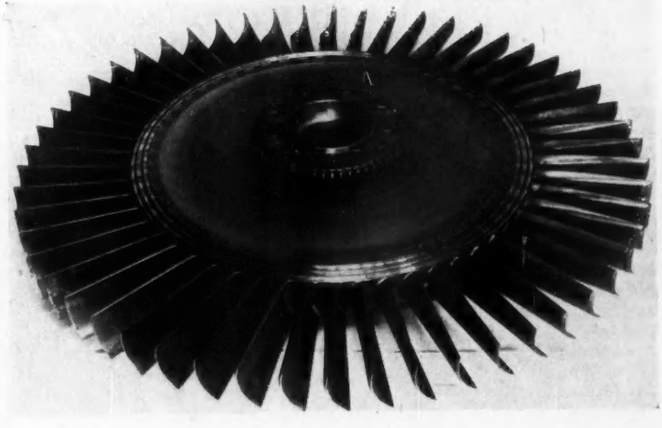


Fig. 1 This gas-turbine disc was originally made from a forging of a "strategic" alloy and weighed 148 lb. By applying air cooling to the disc it was possible to use a lower alloy and to reduce the weight by 24 lb.

* Lecture delivered before the Institution of Production Engineers, Derby Branch, on December 14, 1953. Abridged.

† Of Rolls-Royce Limited.

* Royal Society of Arts, Howard Lectures on "Diesel Engines," Nov.-Dec., 1931.

† Sixth Thomas Lowe Gray Lecture, Inst. Mech.E., Dec., 1933.

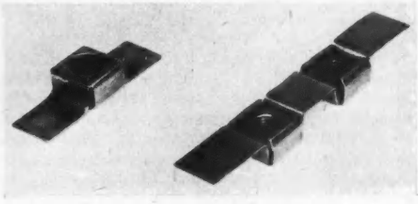


Fig. 2 The cost of these doublecage-nuts is much less when they are made on a battery of four simple fly presses than when fully-tooled machines are used.

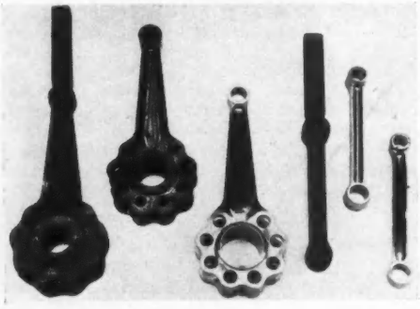


Fig. 3 This radial-engine master rod, which transmits over 1,000 h.p., weighs 9¼ lb. and is machined from a forging weighing 42lb. – a material utilisation of 22 per cent.

Fig. 4 Turbine blade for a Dart engine. It is forged to size on the aerofoil and on the platforms so that these surfaces require no machining other than radiusing of the leading and trailing edges.

disc, it was possible to use, instead, a much lower alloy, and at the same time to reduce the weight of the finished disc by 24 lb. The net saving in cost of the forging was £89. Incidentally, this disc transmits 10,000 h.p.

The prototype of development engineers was Richard Trevithick, who in 1804 broke away from the tradition of the heavy and cumbrous atmospheric engines of Boulton and Watt, and introduced high-pressure steam. He had to develop a boiler to withstand pressures of up to 150 lb. per square inch, and the Cornish and Lancashire boilers still follow closely his original design. In one leap he multiplied the power output of a given size of engine several times, and not only made railway locomotion possible, but pioneered it as well. This work caused about as big a stir as that of the gas-turbine engine to-day.

Returning to the aircraft engine, the overhaul life of the civil Merlin 724 engine was raised by development from 600 hours to 1,250 hours, for an increase in weight of only 70 lb. and only a small increase in cost. This engine is one of the latest of a long line of basically similar ones of 27 litres capacity which started in the last war as a 1,000-b.h.p. engine, and finished at nearly 2,000 b.h.p., again largely through development.

RATE AND SCALE OF PRODUCTION

Considerable responsibility rests upon the production engineer and management alike to ensure that the choice of machinery and methods, and the type of tooling, are properly matched to the scale of production. There has of late been a good deal of misunderstanding here, owing, in the main, to too loose a use of the terms "increased production," "large scale production" and "mass-production." As a consequence, the special techniques of design and tooling and production which have been developed to meet the needs of the motor-car and ancillary industries, for example, are too often held up as models for all to copy.

The greater part of British industry is, in fact, not employed on mass-production at all, which is perhaps a good thing since it gives full play to our genius for extemporisation and flexibility. This has an important and perhaps somewhat unexpected effect upon material utilisation in minimising scrap and wasted effort due to modifications. For instance, in the case of large bomber aircraft during the war, the productive man-hours per pound of aircraft were almost identical for similar British and American machines. As modifications became necessary to overcome defects, or to meet tactical or strategic needs, they were introduced quickly and smoothly into the British aircraft, without interrupting the production flow or reducing the output. In the United States, the planned "mass-production" lines were so rigid that the factories had to go on producing obsolete aircraft which were then shipped hundreds of miles away to modification centres where the new parts were fitted and the old thrown away.

At the opposite end of the scale, a free and unfettered outlook, capable of turning away from the orthodox and getting right down to fundamentals, can save enormously by resisting the temptation to spend unnecessarily on equipment of high capacity, and to use common sense instead. The double cage-nut shown in Fig. 2 is a good example. Planned along textbook lines, this item, which is required in tens of thousands, would be made from steel strip, on a battery of roll feed and dial feed presses costing about £3,600, with tools costing about £500, and at a rate of say 40 per minute. It is actually produced at the same rate, on a battery of four fly presses costing say £140, with tools costing about £30. By using off-cuts, which would be impossible on the automatic machines, the selling price is considerably below that of the fully-tooled job.

Since the highest possible performance must be obtained from every component of the aircraft engine, the form which is best suited to the conditions of duty, such as forging, casting, or fabrication, must be employed in each case.

The claims put forward for any new process are viewed most critically, and in many cases the chief value of a new process has been to provide a spur to a fresh analysis of the shortcomings of the existing method, which it has been found possible to improve beyond the standard of the new one, thus avoiding the delays and expense which would have been incurred by re-equipping and learning. It is especially important to ensure that any new method shall not restrict the scope for rapid expansion of production in an emergency.

FORGING

The need for absolute reliability in the highly-stressed moving parts of the aircraft engine has meant that crankshafts, connecting rods, pistons, valves, and gears have for many years been machined from forgings whatever the type and make of engine. The chief influence of the aircraft-engine industry here has been due to its insistence upon absolute cleanliness of the metal, accurately-controlled forging to give the most appropriate grain flow, and withal the development of materials of ever-increasing strength, which has intensified considerably the task. For instance, ultimate strengths of 65 to 75 tons per square inch for nitriding crankshaft steels, 100 tons per square inch for case-hardening steels for radial-engine connecting rods, and 85 tons per square inch for case-hardening gear steels, were normal for the engines of the last war. Machining and finishing all over were of course essential, as much to provide the highest possible resistance to fatigue as to reduce weight to a minimum. For example, the radial-engine master rod shown in Fig. 3 weighs 9¼ lb. and has been machined from a forging in 100-ton case-hardening steel weighing 42 lb., a material utilisation of 22 per cent. This figure needs to be regarded in the light of the fact that the rod is transmitting over 1,000 brake horse-power.

With blade shapes and methods still in a somewhat fluid state, it is perhaps a little too early to be definite concerning the ideal solution, and since there is in addition a wide variety of design practice in the form of root fixing, it is possible that more than one method may persist. In the author's personal opinion, however, there is little doubt that precision forging of the aerofoil will always play a big part.

This is one of the cases in which the engine manufacturer has had to master a trade and point the way. This is exemplified by the turbine blade of the Dart engine, Fig. 4, which is forged to size on the aerofoil and on the platforms, so that these areas require no machining other than the "radiusing" of the leading and trailing edges after the flash has been clipped off.

CASTING

Intrinsically, the casting method ought to give us by far the cheapest metallic shapes, since moulding enables almost any form to be produced, and the scrap material, from runners and risers, takes the shortest possible route straight back into the furnace. That castings are not in general use for highly-stressed moving parts is due in the main to a widespread distrust which can usually be traced back to some unfor-

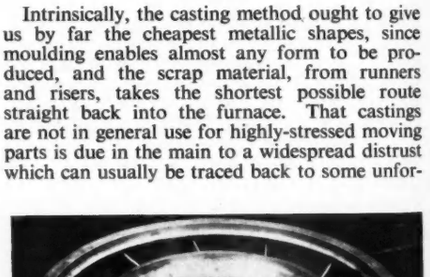


Fig. 5 Exhaust casing of composite construction to overcome machining difficulties: two castings with welded-in radial members.

Fig. 6 Structural stainless-steel castings.

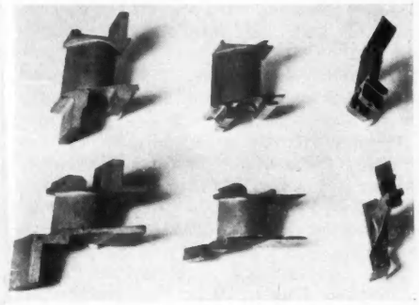


Fig. 7 Nozzle guide vanes produced by the most expensive casting process – lost-wax investment casting.

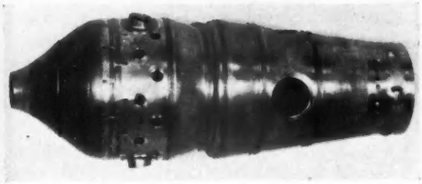


Fig. 8 Rolls-Royce Derwent flame tube, through which air flows at the rate of 20 tons an hour. It is made to very close tolerances from light-gauge Nimonic sheet.

tunate experience. Still referring to the aircraft engine, in the larger sizes of static parts, castings cannot always be produced to the dimensional accuracy and thinness which is dictated by the insistence upon lightness. They find their widest application therefore in light-alloy static casings, where the effect of dimensional errors is not so great; to iron castings which can be machined all over; and to precision castings in high-temperature alloys for smaller static parts such as nozzle guide vanes.

Where operating temperatures preclude the use of light alloys, iron and nickel-chromium steel castings are used, and are machined all over to obtain consistent thicknesses. Where it is not possible, by reason of the shape, to machine all over, recourse may be had to a composite construction as shown applied to the exhaust casing of the Rolls-Royce RM.60 engine, Fig. 5. Here two centri-castings are used, machined to section on one side only, before having the radial members welded in. It is encouraging that in one foundry at least, making static castings, tolerances of $\pm$ 0·005 in. on as-cast diameters of 30 in. or more, are within sight of achievement. Further development is urgently needed to enable castings to be produced to the desired thickness, without machining.

During the past few years there has been a tendency to replace cast structures by "weldments." Cases have been made out showing appreciable savings in weight and reduced cost owing to the fact that no pattern is required. This is perfectly true when comparing steel with cast iron, and when considering "one-offs," but Fig. 6 shows that cast-steel structural members are staging a "come-back," in this case in a marine application, and where even quite small quantities are required, the cost of the pattern is very soon paid for by the saving in time in cutting out the steel plate and jigging and welding it up and inspecting the welds.

Where shapes are difficult to machine, as in the nozzle guide vanes shown in Fig. 7, the most expensive casting method – lost-wax investment casting – can be justified. These components are cast to size on the aerofoil and the platform. The small size of the cored holes should be noticed, and in passing it may be mentioned that these are not by any means the longest cores of their size which are being produced.

FABRICATION

Fabricated sheet-metal parts occupy an important place in the aircraft gas turbine engine, for flame tubes, discharge nozzles, air casings, exhaust units, and jet pipes. The flame tube of the Derwent engine is shown in Fig. 8. Material utilisations as high as 56 per cent. are obtained with these components, and they play a substantial part in the low specific weight of the gas-turbine engine.

These components, and the flame tubes in particular, are interesting as representing an incursion into new fields of accuracy in sheet-metal parts of their size. The flame tube is made from light-gauge Nimonic sheet, and since the efficiency of combustion and the life of the flame tube itself depend upon the accurate guiding and metering of a stream of air flowing through it at about 20 tons per hour, along carefully predetermined paths, it must be made extremely accurately. Since it is required in not very large quantities as compared with what is usual in the precision sheet-metal field, and since the material is extremely difficult to form, requiring several anneals and draws in easy stages for many of the components, it has presented new problems of tooling and manufacture.

The pressings must be free from internal stress, the welds must be of the first quality, and all free edges, as at joints and round the holes, must be carefully radiused and polished. The composite construction too entails great accuracy of trimming and locating to ensure that joints fit properly and that the overall tolerances on the assembly shall be met.

COSTS OF FABRICATED COMPONENT

The subdivision of the costs of material and the different manufacturing operations is rather revealing, as shown in Table I.

TABLE I. BREAKDOWN OF CONSTITUENT COSTS OF TYPICAL FLAME TUBE

Material and Operation	Percentage of Total Cost
1. Raw Material	45·5
2. Pressing, Forming and Shaping	6·7
3. De-burring, radiusing and flash removal	14·2
4. Preparation for welding, i.e., cleaning, jigging and tacking	9·0
5. Welding and Brazing	8·3
6. Machining	12·0
7. Miscellaneous handiwork, etc.	4·3

The small part played by pressing and forming, and the relative importance of machining, locating, welding and finishing, are particularly noteworthy. This analysis is useful as indicating the directions in which efforts should be directed to reduce costs. One thing is immediately apparent – the cost of a multiplicity of constituent components as affecting machining, locating and welding. This is the biggest drawback of fabricated construction, and due account needs also to be taken of the cost of tooling, which will be roughly proportional to the number of constituent components.

Where a complex casting is replaced by a composite fabrication there will be in general an increase in cost, owing to the amount of tooling, accurate trimming, machining and handwork to control and correct welding distortion. In special cases, however, fabrication may be cheaper than a cast construction, and the following example well illustrates the danger of making too sweeping generalisations.

Fig. 9 shows the original oil cooler of the Griffon power plant for the Shackleton aircraft. This had an outer and inner casing of cast magnesium. These had to be machined to close limits, and difficulty was experienced in obtaining castings sound enough to withstand the test pressure of 100 lb. per sq. in. at 150 deg. C., and in sealing the flow baffles against the inner casing. By reverting to orthodox sheet-metal construction, using rolled and swaged brass sheet, Fig. 10, the weight has been reduced from 65 lb. to 46 lb. and the cost has been reduced by 9 per cent.

Another rather striking example of sheet-metal construction, in which the material utilisation is 90 per cent. is the cooling-medium radiator, Fig. 11, of the Merlin power plant used in North

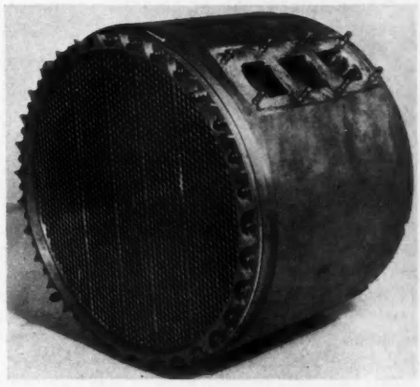


Fig. 9 Oil cooler with casings as originally made of cast aluminium. Difficulties were experienced in production by this method.

Fig. 10 Oil cooler with casings made from rolled and swaged brass sheet.

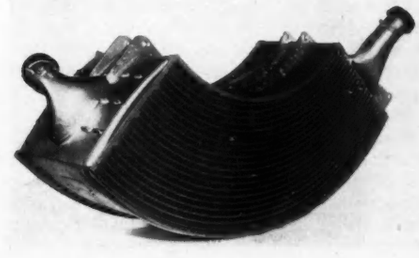


Fig. 11 Coolant radiator made entirely from light alloy. In this form it weighs only 71½ lb.

Star and Argonaut aircraft. This radiator, made entirely of light alloy, is dip-brazed by the Marston Excelsior process. It weighs 71½ lb. as compared with 181½ lb – an excellent example of aptness for purpose, and it is up to 18 per cent. cheaper.

PLASTIC LAMINATE

This is perhaps the place to mention the latest competitor of sheet metal – the plastic laminate. Reinforced with glass or other substance, plastics are providing a serious threat to steel for motor-car bodies, and weight savings of up to 45 per cent. in body panels and hard tops are being obtained. With some of the latest reinforcing materials (not glass), costs 15 per cent. lower than those of orthodox steel parts are claimed.

Acknowledgment is made to the following firms for the use of photographs: Mark Perks, Ltd. (Fig. 2); Bristol Aeroplane Co., Ltd. (Fig. 3); Firth Vickers Stainless Steels, Ltd. (Figs. 5 and 6); J. W. Lawrence, Ltd. (Fig. 10); and Marston Excelsior, Ltd. (Fig. 11).

COLLIERY SLUDGE AS POWER STATION FUEL*

PLANT AT EMILE HUCHET STATION

By R. Gibrat and F. Chenin†

The Emile Huchet power station at Carling, and the Grosbliederstroff station on the River Sarre, the installed capacities of which will eventually be 400 MW and 200 MW, respectively, have been designed to burn the sludge which is produced in the washeries of the neighbouring Lorraine coalfields. This sludge consists of particles up to 0·1 in. in diameter, with a large proportion finer than 20 mils, and has an ash content of from 25 to 50 per cent. and a moisture content of about 30 per cent. after draining.

The sludge is taken from the washers in trucks and emptied into a storage bin about 400 ft. long and 30 ft. deep with tiled sides, consisting of a steeply sloping hopper to prevent adhesion, and an almost horizontal stoppage and storage plate, which ensures against mass discharge on to the underlying belt conveyor. This conveyor, which runs along one edge of the storage plate, is fed by two electrically-driven scrapers which extract the sludge at a rate which can be varied by the operators. One of these scrapers runs on the floor of the storage bin, while the other is suspended from the roof. Both are supplied from cables which are wound on a drum, an arrangement which has been found more reliable than bare trolley wires in the damp and dirty atmosphere. The sludge is then discharged on to other conveyors which take it either to storage or to the drying plant.

SLUDGE PUMPING

The concentrated sludge is diluted with sufficient water to give the correct concentration for pumping and is supplied to the pumping station, whence it is transmitted to the Emile Huchet power station. The pumping station contains five main units, one of which can be driven by a 400-h.p. motor at 1,450 r.p.m., or by a 135-h.p. motor at 965 r.p.m., while the other four (one of which is a stand-by) are driven by 400-h.p. motors at 1,450 r.p.m. These pumps are connected through a system of delivery pipes to isolating valves, so that they can be coupled in series or isolated. An independent circuit, which is supplied at low pressure from a tank, feeds four auxiliary pumps which are coupled to the main units.

The concentration of the mixture is determined by sampling and the results enable an electronic instrument, consisting of a radioactive source placed between the sludge pipe line and an identical pipe filled with pure water, to be calibrated and checked. On each side of these two pipes is a Geiger-Müller counter, which is connected to an integrator and shows the difference between the rates of the two counters, this difference being a direct function of the concentration of the sludge in the pipe line.

The delivery pumps, specially designed for the transport of highly-concentrated sludge, are provided with two shaft extensions so that they can be coupled to two different motors. They consist of a single cast-steel cylinder, which is in two parts divided by a horizontal joint, so that the interiors can be inspected without uncoupling or dismantling any piping. The double suction hydraulically-balanced runner is designed to reduce erosion and is encased in two protecting side plates and a volute to protect the cylinder. The fluid-tight packings have special bushings, which can be washed and cooled with clean water. The present installation enables up to 250 tons of dry product to be delivered per hour.

PIPE-LINE DESIGN

The welded rolled-steel pipe line into which these pumps discharge is 5·7 miles long and 14·8 in. in diameter. It is buried along a railway track on a slightly rising gradient. In designing it special attention was paid to resistance to abrasion, to its behaviour in case of accident and to the possibility of water hammer being transmitted.

Mechanical abrasion of the interior surface of the pipe line is not serious so long as laminar flow is not upset and so long as turbulence is minimised. It was therefore deemed unnecessary to employ any material other than standard welded rolled steel. The problem of suitable valves and fittings is more complicated, since it is essential for their openings to be an accurate extension of the pipe upon which they are fitted. Most of the ordinary "heavily-laden water" valves are therefore unsuitable, as not only do they fail to solve the abrasion problem, but often result in undue wedging, owing to the settlement of solids.

The valves and fittings used are of two different types. In the pumping station they consist of cocks with plugs of special steel, which form a perfectly continuous bridge between the two sleeves that act as connections to the pipes. On the pipe line itself the sludge valves have a moving element consisting of a disc pierced with a hole. Rotation of one third of a revolution either brings this hole opposite the pipe line or completely retracts it into the casing. Neither of these fittings causes any discontinuity of flow, since they form a uniform connection between the upstream and downstream piping. They cannot be wedged by solid particles since the moving elements produce no alteration in the volume of the sludge.

To avoid the disastrous flooding which might be caused by a breakage of the pipe line, the latter has been sectionalised at eight points by remote-controlled motor-driven disc valves. One of these valves, which is inside the pumping station, is closed automatically in case of accident, especially pump failure. The other seven are operated by hand.

TRANSMISSION OF WATER HAMMER

It has been found that the starting and stopping of a pump requires no special precautions other than the gradual operation of the appropriate valves. It has also been found that a sudden stoppage of all the pumps does not cause sufficient disturbance to warrant the installation of anti-water hammer devices. It was, however, necessary to relate the closing time of the first valve to the characteristics of the pipe, so as to limit the effect on its disc of the reflected wave from the other end of the line, set up by tripping.

To ensure the complete transportation of solid matter it is essential that all the particles should be in total suspension and that none should drift along the bottom of the pipe line. Such drifting is influenced by the slope of the pipe and may cause accumulations of heavy particles at low points, with spasmodic evacuation when the speed of the fluid exceeds the critical speed of suspension.

This critical speed increases with the size, density and concentration of the particles, but in a heterogeneous mixture, such as sludge, the larger foreign particles impose their critical speed on the whole. These particles, which are relatively few in number and may only appear at certain times, are easily overlooked. The result is that the minimum pipe speeds for a given composition and granular size in relation to the concentration of the transported mixture are a little too low. On the other hand, the difference between the calculated speed and the actual speed decreases as these speeds increase.

The first operating speed available – 7 cub. ft. per second – is therefore inadvisable, if there is a possibility of large foreign particles entering the pipe line. The second speed of 8·8 cub. ft. per second is satisfactory, except in the case of particularly large particles, while the normal speed – 10·9 cub. ft. per second – gives a safety margin against any incident. These abnormal phenomena have not affected the operation of the pipe line, no obstruction or even partial stoppage having been encountered sufficient to cause a noticeable variation in the discharge pressure of the pumps.

SLUDGE TREATMENT

The sludge is discharged from the pipe line into a pit, whence it is delivered to the screening plant. This plant consists of an underwater screen, which divides the mixture into two categories of granular sizes below and above 24 mils. The larger sludge, after passing through three further screens is centrifuged in hydro-extractors, where its water content is reduced to 10 to 15 per cent., while the smaller is thickened and delivered by compressed air pumps to filters in which its water content is decreased to about 25 per cent. The three screens mentioned are of the vibrating type and are sprinkled with 0·5 cub. ft. of water per second to obtain good separation. Each can deal with 40 tons of dry product per hour and deliver material exceeding 24 mils in size with a water content of 30 per cent. to each hydro-extractor at the rate of 26 tons per hour. The final water content of the treated product is 10 to 12 per cent.

The hydro-extractors are provided with co-axial truncated conical drums, between which the sludge is introduced. The outer drum carries the filters, which are of 59-mil. electrolytic nickel that has been drilled by a photogravure process. The two thickeners consist of settling and decanting tanks 100 ft. in diameter, each of which can deal with 42 tons per hour of material less than 24 mil. in diameter.

The four vacuum filters, which have a working surface of 850 sq. ft., are provided with eight discs of ten sections. These are covered on both faces with a bronze gauze reinforced with a supporting gauze of larger mesh. Filtering does not actually occur through this gauze, but through the first layers of cake that are formed. The slime cake is removed from the gauze by breaking the vacuum and creating a sudden excess pressure inside the section, which actuates wiper blades. These blades also deflect the detached cake, thus reducing the wear on the

* Paper entitled "The Transport, Preparation and Utilization of Colliery Tailings at the Emile Huchet Power Station," submitted for discussion at a joint meeting of the British Section of the Société des Ingénieurs Civils de France and the Supply Section of the Institution of Electrical Engineers, on Wednesday, February 24. Abridged.

† Dr. Gibrat is in the Corps des Mines and is also Professor of Industrial Electricity at the École Nationale Supérieure des Mines de Paris. M. Chenin is with the Houillères du Bassin de Lorraine-Saint Avold.

gauze. The filter slimes are delivered either to store or to driers, while the overflow water, which contains a certain quantity of very fine particles, is transmitted to hydraulic dust removers.

WORKING RESULTS

By April 1, 1953, the plant described had delivered 60,000 tons and experience had shown that obstructions in the pipeline were very unlikely to occur. In fact, the only stoppages recorded have been due to interruptions in the electricity supply and although these caused settlement of the slime throughout the pipeline, a state of fluid suspension was always regained without difficulty when operation was resumed. In laying the pipeline precautions were taken to ensure that particles after settlement could not accumulate at the low points. The result is that when an unexpected stoppage occurs an almost uniformly thick layer with reduced cohesion is formed and suspension is resumed without difficulty when the transporting fluid regains its normal speed. These conditions do not arise when the stoppage is intentional, as the pipeline is then rinsed with clean water before the pumps are shut down.

Wear of the pipe and of the valves described above has been small and that of the delivery pumps has been less than is considered normal with heavily sludge-laden water. Improvements, which would eliminate harmful elements from the treatment circuit proper, are being considered, but on the whole the installation seems to be economical and convenient in operation, providing sufficient water is available for transport. The principal advantage of a single large plant, such as that at the Emile Huchet station, is that its initial and operating costs are lower than those of a number of small plants. On the other hand, the cost of transportation by pipeline is not yet known, although it is hoped it will not exceed one-third that of rail transport. The relief of the railway system and the convenience and cleanliness of operation are other factors in favour of pipeline transportation.

DRYING EQUIPMENT

As the sludge tends to agglomerate the problem of drying it is difficult, but it seems that the solution is to use pulverised coal crushers which can deal with fuels of a high moisture content. Standard equipment has therefore been chosen, consisting of two Modave driers with a rated flow of 20 to 25 tons per hour and two Buttner driers with a rated flow of 32 tons per hour. All four driers reduce the critical moisture content of 20 to 28 per cent. to 6 to 8 per cent. By using a large spreading surface it is possible to employ low gas speeds, so that dust pick-up is minimised and extractors are unnecessary.

The most difficult problem is to ensure the regular and adjustable delivery of sludge to the driers. Breakers may be necessary, but with sludge of the relatively small agglomerating quality so far met with these have not been required. Jigger screens at the receiving end, which remove large non-magnetic particles, have given good results. The driers must also be regulated so that their output is not so dry as to raise dust during its transit to the power plant.

STEAM-RAISING PLANT

The two 110-MW generating sets at the Emile Huchet station are each supplied from four boilers, the individual output of which is 270,000 lb. of steam per hour at a pressure of 1,600 lb. per sq. in. and a temperature of 990 deg. F. These boilers are of the natural circulation water-cooled furnace type with a heating surface of 22,000 sq. ft. and are fired with pulverised fuel through 12 tilting burners. The combustion chamber volume is 27,000 cub. ft., owing to the low ash fusion temperature of the Lorraine coal making a low combustion temperature essential.

Soot blowing is effected by compressed air blowers which are driven by 900 h.p. motors and are started automatically according to a pre-determined cycle. Steam soot blowing was not used, since in a high pressure plant any steam not returned as condensate has to be made up with treated water which is costly. Moreover, all the auxiliaries are electrically driven and it would have been inadvisable to make an exception in the case of the soot blowers.

The boilers are lighted and the temperature raised by gas burners, which are supplied from a neighbouring coking plant. They are kept alight on low loads so as to prevent any risk of explosive re-ignition of the coal. When a set is started from cold it begins to operate when the steam pressure reaches 700 lb. per sq. in.

DUST AND ASH DISPOSAL

It is expected that the incombustible material, consisting of a certain quantity of ash from the base of the combustion chamber and of fly ash collected in the arresters and boiler hoppers, will amount to about 1,200 tons per day. The former, which represents about 10 to 15 per cent. of the total, will be moistened and deposited on a conveyor from which it will be loaded into railway wagons. Practically all the ash formed in the combustion chamber circulates through the whole gas circuit and is trapped in Modave hydraulic arresters just before reaching the induced draught fans. The ash-laden water from these arresters is collected in a trough which leads to a tank. This tank is discharged by gravity at the rate of about 10 cub. ft. per second to a low lying valley 1·3 miles from the station where an earth dam 80 ft. high is being constructed.

A small percentage of ash is also collected in hoppers below the superheaters and economisers and is withdrawn through rotating locks driven by water turbines. The exhaust water from these turbines removes the extracted dust in suspension and carries it to two underground tanks. It is pumped thence to the collecting trough under the dust arresters and mixed with the main flow, which is evacuated to a settling basin.

Owing to the water being dust laden the exhaust pipes are duplicated and their inlets are closed by rubberised plugs since no valve would withstand the operating conditions. The cast-iron pipes inside the power station are being replaced by others with a lining of basalt, which are expected to behave perfectly on partial load without added water. These pipes operate under extremely variable conditions since the flow ranges from 6 ft. to less than 2 ft. per sec. All the particles are not therefore totally suspended, notwithstanding the fineness of the ash. These pipes have been laid on a constant falling gradient so that the larger particles drift along the bottom. In the case of any interruption in supply they are completely emptied so that no solid matter accumulates. This is important since the cohesion of the sediment would prevent the resumption of suspension after a protracted stoppage.

LAUNCHES AND TRIAL TRIPS

M.S. "HALLINGDAL."—Single-screw oil tanker, built and engined by Burmeister and Wain, Ltd., Copenhagen, Denmark, for Boe and Pedersen, Oslo, Norway. Main dimensions: 465 ft. between perpendiculars by 62 ft. 10 in. by 34 ft. 8 in. to main deck; deadweight capacity, 13,400 tons on a summer draught of 27 ft. 6¾ in.; oil-tank capacity, 17,870 cub. metres. Five-cylinder single-acting two-stroke oil engine, developing 4,600 b.h.p. at 115 r.p.m. Speed, 14 knots. Trial trip, January 6.

M.S. "INGER SKOU."—Single-screw cargo vessel, built and engined by Burmeister and Wain, Ltd., Copenhagen, to the joint order of Ove Skou Ltd., and The Shipping Company of 1937, Ltd., both of Copenhagen, Denmark. Main dimensions: 400 ft. between perpendiculars by 55 ft. 6 in. by 35 ft. 6 in. to upper deck; deadweight capacity, 6,850 tons on a draught of 24 ft. 4 in.; cargo capacity, 430,000 cub. ft. bales. Eight-cylinder single-acting two-stroke Diesel engine, developing 8,700 i.h.p. at 125 r.p.m. Speed, 17 knots. Launch, January 21.

M.S. "RAMBLER ROSE."—Single-screw cargo vessel, built and engined by John Lewis and Sons, Ltd., Aberdeen, for Hughes Holden Shipping, Ltd., Swansea. Main dimensions: 255 ft. between perpendiculars by 35 ft. 6 in. by 15 ft. 9 in. to upper deck; deadweight capacity, about 1,600 tons. Lewis-Doxford three-cylinder opposed-piston oil engine, developing 1,100 b.h.p. at 145 r.p.m. Launch, January 21.

M.S. "VINTERLAND."—Single-screw cargo vessel, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, for Angfartygs A/B Tirfing-Svenska Orient Linien, Gothenburg, Sweden. Sixth vessel of this type built for these owners. Main dimensions: 400 ft. between perpendiculars by 57 ft. 8 in. by 25 ft. 3 in. to main deck; deadweight capacity, 5,800 tons on a draught of about 23 ft. 7 in. B. and W. seven-cylinder single-acting Diesel engine, developing 6,700 i.h.p. Speed, 16·5 knots, fully loaded. Launch, January 23.

M.S. "ELLEN BAKKE."—Single-screw cargo liner, built and engined by the Götaverken Shipyard, Gothenburg, Sweden, for Knut Knutsen O.A.S., Haugesund, Norway. Main dimensions: 507 ft. overall by 63 ft. 6 in. by 41 ft.; deadweight capacity, 10,300 tons on a draught of 28 ft. 6 in. Götaverken nine-cylinder single-acting two-stroke Diesel engine, developing 8,200 b.h.p. at 112 r.p.m. Loaded speed, 17 knots. Launch, January 27.

FARM-TRACTOR ENGINES

Diesel or Vaporising Oil?

Diesel engines in agriculture was the subject of a paper presented to the Diesel Engine Users Association at a meeting held in Caxton Hall, London, on February 18, by Mr. L. Martland, A.M.I.Mech.E., and Mr. R. M. Ogorkiewicz, B.Sc. (Eng.). It covered a study which had been made of a wide variety of engines for use in farm tractors.

The authors favoured narrow engines fitted with wet liners and direct-injection fuel systems because of their good cold-starting characteristics. The fuel-injection equipment, they said, represented a fifth of the engine cost. To overcome the formation of hard carbon on valve stems, valve rotors of the Eaton type were used.

The Diesel-engined tractor proved, in comparative tests, to be far less exacting and sensitive than the vaporising-oil engined type. It required fewer oil changes and was easier to start, as a second fuel was not required. The lack of ignition equipment also made it more reliable in wet weather. In fact, it was considered that, for a medium sized tractor, the vaporising-oil engine was only economical when used for less than 500 hours a year.

By plotting some 22 test results, produced by the National Institute of Agricultural Engineering, it was shown that the average fuel consumption of the Diesel tractor was 66 per cent. of that of a vaporising-oil type, while at half load it was only 50 per cent.

Important though it was, fuel consumption did not represent the whole story of operating costs. The first cost of the power unit also entered into it and partly offset the advantage of the lower fuel consumption of the Diesel engine. In this country, an average Diesel-engined tractor initially cost 20 per cent. more than one with a vaporising-oil engine.

TRANSMITTING ANGULAR AND ROTATIONAL MOVEMENT

THE SCOPE OF SELSYNS

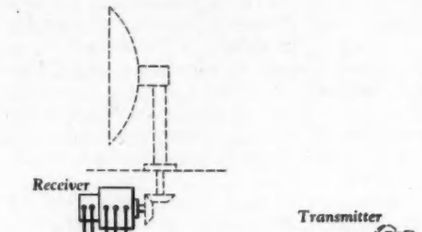


Fig. 1 General-purpose selsyns as used in an aerial turning gear.

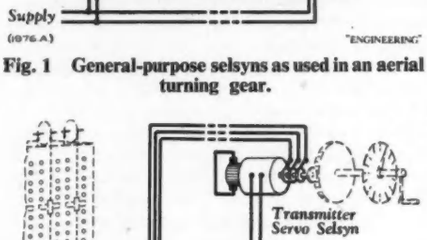


Fig. 2 A power-amplifier system reduces the fatigue of continuous operation by hand. In this application, the receiving selsyn is controlling a bank of rheostats.

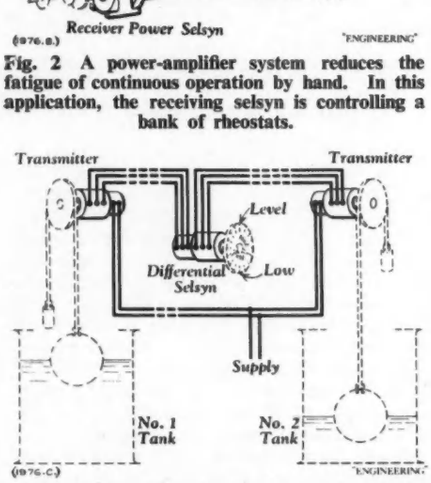


Fig. 3 Differential selsyns can be used, as in this example, to show the difference between the liquid levels in two tanks. They can also be used to show the difference in speed of the two transmitters.

The selsyn is a type of electric machine similar in many respects to a slip-ring induction motor, but of special characteristics to enable two or more units to be operated so that angular motion or torque can be transmitted electrically from one to the other, or a voltage can be generated in one corresponding to the angular displacement between the two rotors. The system is analogous to an infinitely flexible shaft transmission and, as such, has a very wide range of application.

In its simplest form a selsyn system consists of a transmitter selsyn and a receiver selsyn between which there is an electrical tie. Generally both selsyns are excited from an alternating current supply, and any movement of the rotor of the transmitter is reproduced by the rotor of the receiver. As with the analogy of the flexible shaft transmission, there is always a slight angle of lag between the two. This angle increases with an increase in transmitted torque, although it is generally very small at low torques. One transmitter can be connected to operate several receivers, providing it is of sufficient size. Considerable experience has been gained in selsyn operation during the years they have been in use in both industrial and military applications, which has resulted in a range being produced for various special purposes. The types may be approximately defined as: (1) general purpose, (2) precision, (3) power amplifiers, (4) differential, (5) servo position-control, and (6) power transmission.

GENERAL PURPOSE, POWER AND PRECISION TYPES

Where great accuracy of correspondence between transmitter and receiver is not required, the standard general-purpose type can be used. They are robust, and are built for continuous operation, being capable of transmitting considerable torque. A typical application is to the rotating gear of radar and other aerials (Fig. 1). Their use enables the power and control units to be located at any convenient point, irrespective of the position of the aerial. Precision selsyns are similar to the general-purpose models but are built for very low friction, and the angular difference being transmitter and receiver when transmitting small torques is as low as one degree. The indication of liquid levels is one application. Power selsyns are similarly built but are capable of transmitting greater torques. Fig. 5 shows one application.

In a conventional selsyn system, the torque output from the receiver is less than the input to the transmitter by the amount of the transmission losses. As in some applications it is not convenient, or (if the drive is manual) would be physically fatiguing, to provide the power input to supply the drive, a system has been developed which will give power amplification. This system is particularly useful where continuous operation is required. Models can be arranged for manual operation only, or for self-motoring with optional manual drive. An example is shown in Fig. 2.

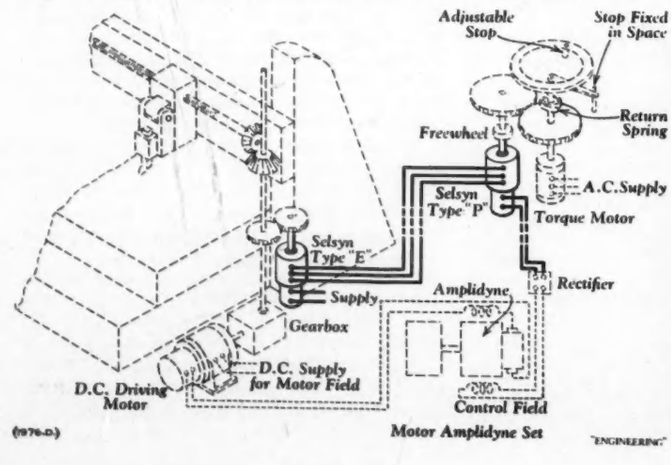


Fig. 4 Position-control selsyns for a planer feed. When a reversing switch is thrown to "cut" the torque motor rotates selsyn "P" until the stop is reached. Selsyn "E" is now out of phase and a voltage is induced in the amplidyne control field. This starts the driving motor which runs until the selsyns are in phase again. When the planer switch is thrown to "return," the torque motor is de-energised and the arm is returned by the spring; the free wheel allows selsyn P to remain stationary.

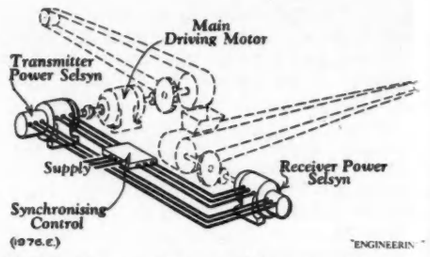


Fig. 5 Power selsyns, enabling one motor to be used to drive two conveyors in synchronism. More than one receiving selsyn can be used as long as the transmitter has sufficient output.

It is sometimes desired to know the difference between two measurements, as, for example, the difference in level of liquids in two tanks, and a selsyn system has been worked out for this. Connections for this system are shown in Fig. 3. Three selsyns are used: two transmitters and a differential receiver which is electrically linked to the other two. Since all selsyns rely on angular displacement, the system can equally be used for measuring the difference in speed between two shafts; in this case the receiver will rotate at the difference speed. Thus by using a servo-system the two shafts can be kept running at the same speed, or at any constant difference. Alternatively, the receiver can be made to rotate at the sum of the speeds of the two shafts.

SERVO POSITION-CONTROL

Small selsyns can be used to control servo systems very accurately. There are two alternative arrangements, using either a transmitter and a transformer or two dual-purpose selsyns. These are coupled to the shafts which are to be synchronised, and if an angular displacement occurs between them a voltage is induced in the transformer selsyn which then puts the main servo-mechanism into operation. The application shown in Fig. 4 is to the feed of a large planer, using a motor amplidyne set in the control system. Constructional errors in this class of selsyn may cause static errors in the shaft of up to ¼ deg., but this can be reduced by using special "coarse and fine" transmission. It is probable, however, that greater errors will exist in the mechanical part of the system.

Very accurate coincidence can be obtained by gearing up the selsyn on the main drive. This has the disadvantage that there will be several positions of coincidence and consequently a direct-driven selsyn is used to overcome this difficulty. This gives the "coarse" control while the former supplies the "fine."

Selsyns are made by the British Thomson-Houston Company, Limited, Rugby (who have issued a leaflet, on which this article is based) and have wound stators and wound rotors with sliprings; power amplifiers have a commutator in addition. Small sizes are for single-phase supply, but the larger ones are usually for three-phase systems. Selsyns should not be run at speeds greater than 80 per cent. of their induction motor speeds, that is two-pole 50-cycle types should not be run above 2,400 r.p.m. and four-pole not above 1,200 r.p.m.

GENERATING PROTECTIVE ATMOSPHERES FOR HEAT TREATMENT

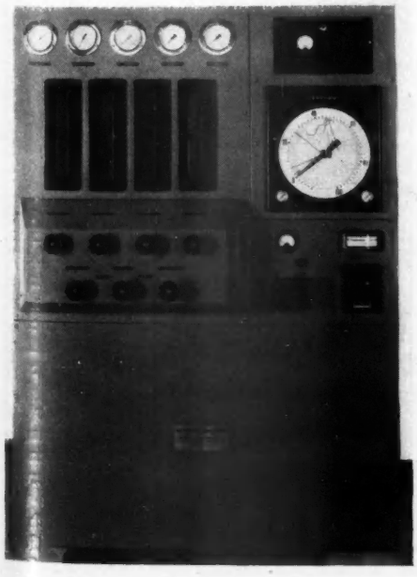
Cracking and Burning Ammonia

The use of controlled atmospheres in the annealing of metals is of increasing industrial importance and, in general, the ideal atmosphere is one which does not react in any way with the metal under treatment. For certain of the rarer metals now becoming of importance, only the truly inert gases, such as helium and argon, can be used, but, for the majority of the metals used in industry, an atmosphere of nitrogen is sufficiently inert. It is desirable, however, to have present in the nitrogen a small percentage of a reducing gas such as hydrogen to react with any adventitious contamination due to the leakage of outside air or the evolution of oxygen from refractories or other parts of the vessel in which the heat treatment is being carried out.

A convenient method of producing mixtures of hydrogen and nitrogen, now used fairly extensively, involves the dissociation of anhydrous ammonia. Cracked ammonia is employed widely in the metallurgical industry, but owing to the high proportion of hydrogen present, the use of the mixture is limited both as regards the scale of the operation and the nature of the work being done. To overcome these drawbacks, and also to reduce the cost, apparatus has been developed in which the cracked ammonia is burnt with a slight deficiency of air to give nitrogen containing a small percentage of residual hydrogen. Provided precautions are taken to ensure the cleanliness of the air and the burnt gas is thoroughly dried, the resulting hydrogen-bearing nitrogen retains substantially the advantages of the original cracked ammonia without its disadvantages. The apparatus needed, however, is relatively large and requires close control. In consequence, its use is economical only in cases in which a large and continuous output is required.

A recent development, the Nitroneal generator, made by Baker Platinum, Limited, 52 High Holborn, London, W.C.1, provides the same type of atmosphere by combining, in one process, the simultaneous cracking and burning of ammonia. The generator employs a platinum-metal catalyst through which a controlled mixture of air and ammonia is passed. The catalyst ensures the complete reduction of all the oxygen to water vapour, which is then removed partly by condensation and partly by conventional driers. The dew-point of the resulting gas depends solely on the efficiency of the drying and can be reduced to −40 deg. C., and even lower, without difficulty. The control panel of the generator, seen in the illustration below, provides for easy adjustment of the ratio of ammonia to air and, subsequently, automatic control ensures constant composition. The hydrogen content of the Nitroneal gas can be varied from as little as 0·25 per cent. to as much as 25 per cent., and a built-in analyser indicates and records the hydrogen percentage. The equipment is available in a range of sizes the smallest providing 100 cub. ft. per hour, and all generators except the smallest are controlled automatically once the original setting has been made. Manual control only is provided on the smallest generator in order to keep down its cost and broaden its field of economic usefulness.

A particularly interesting feature is the rapidity with which the generator can be brought into service. It is claimed that, from a cold start, a satisfactory atmosphere is produced in about 15 minutes and that the composition of the Nitroneal gas settles down to the predetermined figure within a further 10 minutes at the most.



"Nitroneal" generator for producing nitrogen for annealing, containing from 0·25 per cent. to 25 per cent. of hydrogen.

PREVENTING AND REMOVING RUST

The relative ease with which heavily-corroded machinery and equipment, including rust-bound nuts and bolts, shackles and the links of conveyor and other chains, can be freed from rust by the application of a penetrating liquid, was recently demonstrated to our representative. The liquid, "Formula 'A'" de-rusting and dismantling fluid, is a light-coloured mobile inflammable spirit-like substance containing no acid or corrosive constituents and is not injurious to the skin of the operator. It is applied to the bolt, nut, or flange by means of a hand-pressure oil can and, in a few minutes, the rust is broken down and the corroded part may be unscrewed or loosened with little or no difficulty. The judicious use of the fluid enables valuable equipment to be saved which otherwise, might have to be replaced; it also facilitates the work of dismantling machinery.

The manufacturers and distributors of this fluid, the Plus-Gas Company, Limited, 1-11 Hay Hill, London, W.1, inform us that it has found application in coal and other mines for the freeing of conveyor chains, pulleys and cutting and other apparatus; in shipyards and docks for the loosening of rusted winches, shacklepins and bolts in various types of equipment, and in steel foundries in connection with general maintenance work. It is also being used in garages and by farmers and building contractors for freeing seized rings and in the maintenance of lorries, tractors, cement mixers, scaffolding and other plant.

PROTECTIVE LIQUID

The Plus-Gas Company have also placed on the market a "Formula 'B'" protective fluid. This is a resin-based liquid intended to give protection against corrosion. It is applied either by brushing, spraying or dipping and a gallon of the substance will cover approximately 1,200 sq. ft. The coating is transparent and an advantage claimed for it is that it possesses elasticity which enables it to expand and contract with the underlying metal under varying temperatures. It is stated, moreover, that the coating is thin enough to render its removal usually unnecessary before putting the treated parts into use or assembling them into a plant. It has no detrimental effect on lubricating oil and is available in colours, namely, red, gold, green and black, as well as in the transparent form.

It has been adopted for the coating of steel articles before packing them for shipment overseas, and for the protection of colliery equipment, sheet steel, motor-car spare parts and wire ropes. In connection with the latter, we are informed that six months ago the wire ropes operating the elevator of the 600-ft. mast of the British Broadcasting Corporation's television station at Sutton Coldfield were treated with the fluid, since when the lift mechanism has remained in perfect working order.

WORKSHOPS FOR COLLIERY MACHINERY

New workshops, costing between £250,000 and £500,000, are to be built by the National Coal Board at Ashington, Northumberland, to concentrate and speed-up repairs to colliery machinery and plant. Reference has been made to the scheme by Mr. D. Hindson, area general manager for the Northern (Northumberland and Cumberland) Division of the Board at a meeting of area engineers and consultative committees at Ashington.

He said that the Board had approved the scheme in principle and a start on the project was expected later this year. At the outset the workshops would employ 300 men, but would be capable of expansion. Work would be planned on a scientific basis to provide a speedy turnround of machinery, and instead of machines being tended when the need for repairs arose, a systematic inspection and servicing was proposed which would minimise actual repair work. New machines received into the district would be examined, and miners given instructions on their use. It is understood that improved facilities for training apprentice engineers are to be provided at Ashington Colliery.

NEW INSULATING MATERIAL

Processed from Rice Husks

A new material, to be known as "Secondite," is being produced from rice husks by a patented process which extracts all organic matter leaving only silica, cellulose and lignin. The resulting material is claimed to have remarkable properties, some of which, such as flame resistance and heat insulation, were recently demonstrated in London. The material has been developed by Mr. Angelo Secondi as a result of wartime research for synthetic materials in Italy, and it is to be exploited in the United Kingdom by the Secondite Company, Limited, 25, Millbank, London, S.W.1.

It is termite proof and mixed with such binders as cement or magnesite it forms building material having good qualities of heat and sound insulation. When mixed with magnesite it is said to be particularly suitable for pavements or flooring, having the strength properties of concrete combined with the warmth of wood and at the same time being resistant to corrosive fluids and gases such as might be encountered in industrial or laboratory installations. Secondite is also suitable for use as a gas filter.

AN ADAPTABLE WOODWORKING MACHINE

SANDING, SAWING, DRILLING AND TURNING

A woodworking tool which may be adapted to serve as a disc sander, a vertical and horizontal drilling machine, a circular saw and a wood turning lathe has been developed by Smart and Brown (Machine Tools), Limited, 25, Manchester-square, London, W.1. Known as the "Versatool," this machine achieves its versatility by means of supplementary fittings which can quickly be added or removed and which are fixed in place on the machine by means of hand locking screws.

The construction of the machine is basically a tubular steel frame on which are bolted two end supports. These carry the bed-ways, which are precision ground from round steel bar and which extend beyond the supports in order to accommodate such fittings as a rear extension table and a tailstock. The headstock, a tilting table and certain other attachments slide on the bed-ways and may be locked to them. The frame is constructed in such a way that the cylindrical bed-ways may be set in either a horizontal or a vertical position, thus extending the range of drilling and sawing operations that can be performed.

Other parts of the Versatool are a mitre gauge for making inclined cuts ; a rip-fence which can act as a guide or a stop, and may be fixed to either table ; a saw guard and splitter ; a drill chuck and faceplate, and various cutting and sanding tools.

The machine is converted into a multi-purpose circular saw by means of a slotted insert fitted into the main table, through which the saw blade projects, as can be seen in the illustration below. Tilting the table to a given angle – set by means of a protractor scale – provides another method of making inclined cuts, and the rip-fence then acts as a guide.

SAWING AND DRILLING

Material up to 48 in. in length can be sawn by using the extension table, to which the rip-fence can be transferred. Large sheets may be cut by raising the bed-ways into the vertical position and guiding the wood into contact with the blade across the floor surface. The blade, which is then in a horizontal plane, has a maximum distance from the floor of 60 in. The diameter of the saw is 8 in. and the greatest depth of cut is $2\frac{3}{8}$ in., however the equipment is arranged.

To adapt the Versatool for drilling, only slight modifications from the sawing positions are required. Vertical drilling is performed with the bed-ways upright and the table fixed horizontally to them, as a firm base for the workpiece. In horizontal drilling, the mitre gauge serves as a work-steady, and if holes are to be drilled at an angle it may be set accordingly.

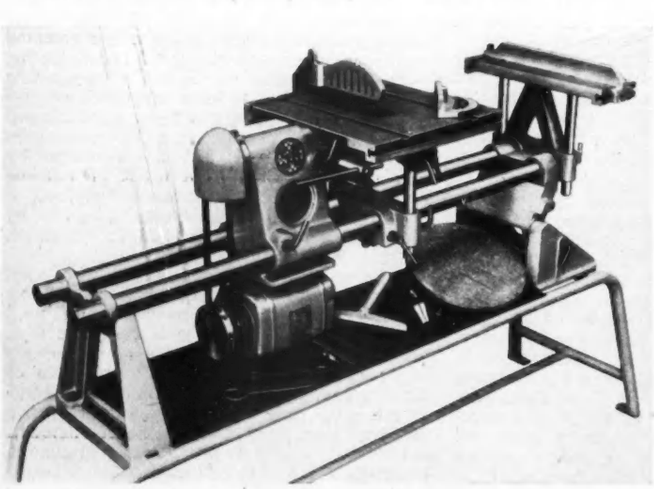
The capacity of the drill chuck is $\frac{1}{2}$ in. The maximum height from the chuck to the table at its lowest position is 30 in., and to the floor, 58 in. The distance from the centre of the spindle to the ways is $7\frac{1}{2}$ in. The machine has a range of six spindle speeds: 3,400, 2,400, 1,700, 1,200, 900 and 600 r.p.m.

The same speeds are available for turning between centres and for this purpose a tailstock is set up on the bed-ways extensions, which are alternatively occupied by the rear extension table. The machine may also be used as a faceplate lathe, and for both turning operations a hand tool rest with a vertical adjustment of $\frac{3}{4}$ in. is fitted to the bed-ways. The distance between centres is 32 in. when the headstock is at the full extent of its movement and the maximum swing is 15 in.

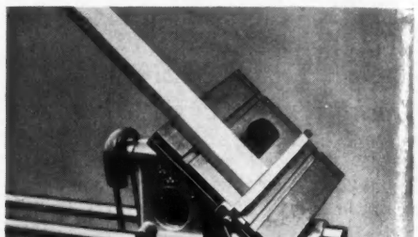
INTERCHANGEABLE PARTS

A sanding disc, 12 in. in diameter, can also be attached to the headstock spindle and such operations as edging, squaring, levelling and mitring may then be performed. For these processes the table is required, and either the mitre gauge or the rip-fence is used as a guide. By means of the rip-fence and stops on the spindle, accurate widths may be cut. The dimensions of the table are 17 in. wide by $14\frac{1}{2}$ in. long. When the extension is in use, the effective length is increased to $38\frac{1}{2}$ in.

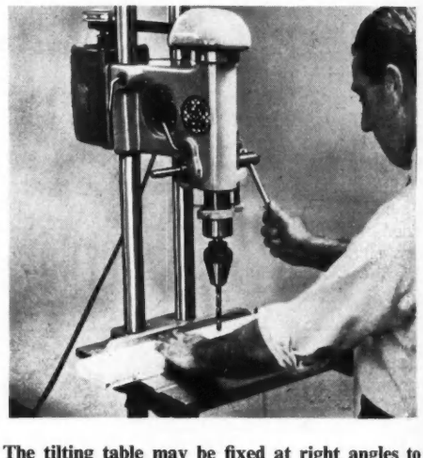
The parts of the Versatool, which are of simple design, are interchangeable with one another, so that rapid adaptation is possible with the use of few tools. The headstock incorporates a ground quill which can be locked in any position. The quill has a full traverse of 4 in. but can be controlled by means of stops, and a scale is provided for that purpose. The hardened and ground spindle nose is internally tapered to accommodate attachments, such as the drilling chuck, sander and saw, which may be secured in place by a locking screw.



The Versatool woodworking machine, which is shown in this general view arranged for sawing with the tilting table in the horizontal position and the mitre gauge and saw-guard and splitter fitted to it, may be adapted for vertical and horizontal drilling, disc sanding and turning. The extension table, to which is bolted the rip-fence, is shown set above the triangular tailstock.



By tilting the table to a given angle, inclined saw cuts can be made. Also shown in this picture is the hinge which allows the bed-ways to be raised to a vertical position.



The tilting table may be fixed at right angles to the bed-ways to provide a base during vertical drilling. The headstock, which carries a $\frac{1}{2}$-h.p. motor, can be locked to the bed-ways by the hand screw shown.

Slung beneath the headstock, and bolted to it, is a $\frac{1}{2}$-h.p. synchronous motor. The drive is transmitted to the spindle through a three-step cone pulley which may be exchanged with the headstock pulley to give the six spindle speeds. The motor is controlled by a rotary switch on the headstock.

LIGHTWEIGHT CONSTRUCTION

The tilting table, which is cast in aluminium alloy, is of box construction and is located on a carriage otherwise used to support the tool rest. Accurate vertical adjustments are made by means of a fine-pitch screw, and pad bolts lock the table once it is in position. The table can be tilted through 90 deg. in one direction and 45 deg. in the other, and can be set by means of a protractor scale in any intermediate position. A locking handle and stops at 45 deg. on both sides enable rapid adjustments to be made.

T-slots in the table provide a means of securing both the rip-fence and the mitre gauge, which is graduated to give an arc of movement of 120 deg. The front of the table is undercut to prevent chatter during bevelling with the sanding disc. The height of the whole machine is approximately 74 in. in the vertical position, and it occupies a space of 18 in. by 66 in. The aluminium fittings and the tubular construction of the frame make possible the Versatool's low weight of 229 lb.

NUCLEAR REACTORS AND POWER PRODUCTION*

By Sir Christopher Hinton, M.A., M.I.MECH.E.†

The first nuclear reactor of any size to be built in Great Britain was the British Experimental Pile (BEPO) at Harwell, completed early in 1948. The British Atomic Energy organisation had been set up in the spring of 1946 and the Research Establishment at Harwell promoted to carry out fundamental long-term research and to devise the physical and chemical processes that would be used in atomic-energy factories. The actual design, construction and operation of these factories was made the responsibility of the Production Division, at Risley, Lancashire.

BRITISH EXPERIMENTAL PILE (BEPO)

At the outset of designing BEPO, a choice had to be made between graphite and heavy water for the moderator. These were the only two suitable materials for a natural uranium reactor for which the necessary information was then available. As it was known that heavy water would not be available for the larger production piles for which BEPO was to be the forerunner, it was decided to build a graphite-moderated pile which was air-cooled.

The main structure at Harwell comprises a graphite core, resting on concrete foundations and surrounded by the main concrete shield and its associated steelwork. The graphite is stacked in the form of a 26-ft. cube, built of 28,000 blocks which are 7¼ in. square by 29 in. long; between each layer of blocks there are series of horizontal channels. The central channels are loaded with uranium to form a reacting core 20 ft. long by 20 ft. in diameter, the remaining 3 ft. thickness of graphite acts as a neutron reflector. Reinforced concrete, 6 ft. 6 in. thick, comprises the main "biological" shield, which is protected from overheating on its inner side by a "thermal shield" of 6-in. thick steel plates.

Charging the core is done through tubes in the shields opposite every channel in the graphite lattice core. The formation and location of these tubes are clearly shown in the photograph which was taken during the construction of the protective shields. When the pile is operating the tubes are plugged by steel ferrules filled with concrete. Extensions of the graphite, "thermal columns," made through holes in the top and side shields, enable powerful sources of thermal neutrons to be available for experimental purposes. These columns are specially shielded.

Between the charge and discharge walls and the face of the graphite there are gaps 4 ft. wide which act as inlet and outlet headers for the cooling air. Cooling is carried out by drawing air through the core in a single-pass system and discharging it via filters and up a 200-ft. stack. An exhauster system was chosen in order to maintain a sub-atmospheric pressure around the core to prevent leakage of radioactive air or of air-borne radioactive dust into the pile building.

Normal control of the pile is effected by four rods of steel tubes, 2 in. in diameter and filled with boron carbide, a neutron-absorbing material. These rods are arranged horizontally at right angles to the uranium channels and are moved in and out by electrical motors. The reactor is shut down by introducing ten similar rods in a vertical direction; provision has been made for automatic shut-down in an emergency.

One of the principal difficulties is to find suitable material and methods for canning the uranium to prevent its oxidation and the release of highly active fission products. It is also necessary to provide some form of extended surface on the fuel elements to achieve the transfer of heat to the air. The canning material must not be a heavy absorber of neutrons, but it has to be selected with regard to its physical properties. Pure aluminium was chosen for BEPO fuel elements and has proved satisfactory.

WINDSCALE PILES

The Windscale piles are, in general principle, similar to BEPO. They are very much larger in size, and they were not built for experimental purposes but for the production of plutonium on an industrial scale.

It was originally intended to build graphite-moderated water-cooled piles since, it was argued, a higher specific thermal rating could be obtained with water cooling. Water, however, absorbs neutrons more readily than graphite, so that any loss of coolant from the core would lead to an increase of reactivity. The failure of the cooling system might have been serious unless the reactor had been constructed on a very remote site. The inconvenience of such a location would have been so great that air-cooling was adopted. Cooling air is supplied by a number of centrifugal blowers, each driven by an 11-kV induction motor developing between 2,400 and 3,000 h.p. The pile chamber is fitted with lagging between the thermal and biological shields, with a cooling space behind it.

Schematic diagrams of one of the Windscale piles are shown in the accompanying cross-sections and half-plan on the following page. As for BEPO, the mass of the graphite moderator lies within a biological shield, though, in this case, the shield has only to provide adequate protection and not, as for BEPO, reduce the escape of neutrons and gamma-rays to the level required for physical research on and around the pile. The shields are also pierced by fewer holes since only limited facilities are provided. For like reason, forced draughts instead of induced draughts are employed for the air coolant, but inlet as well as outlet filters are used as at Harwell. Continuous monitoring of the uranium channels is carried out to detect any burst slugs. Control is effected by rods in the same way as has been described in regard to BEPO.

Loading and handling arrangements were designed for moving cartridges at a much higher rate than in BEPO. The charge platform is located within the main biological shield, but with a subsidiary shield or charge wall separating the charging room from the face of the pile. From the discharge side a water duct passes through the shield and connects with an external storage pond. Irradiated cartridges, discharged from the core, fall into trucks on an under-water railway running along the water duct to the storage pond where they are cooled and de-canned prior to processing in the chemical-separation plant.

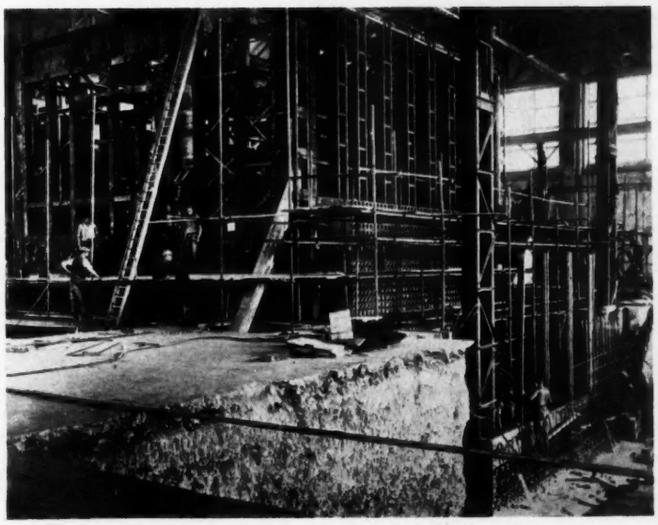
RAFT OF 21,000 SQ. FT.

The Windscale piles are each of considerable size, built as monolithic structures on rafts to avoid problems of relative movement possible if the chimney and pile itself had been on separate foundations. The biological shields, reinforced to resist thermal stresses, were used to secure the rigidity of the monolith. Each raft has an area of 21,000 sq. ft. and supports a load of 58,000 tons. Due to the bearing strata, the eccentricity of loading had to be carefully controlled, not only for the finished structure, but throughout construction.

Construction of the top shield was characterised by the high degree of accuracy involved. The shield consists of a concrete slab 8 ft. 6 in. thick placed above permanent steel shuttering, welded to prevent inward leakage of grout. The whole plate was pre-deflected upwards to offset the deflection to be caused by the concrete. Tubes were welded to the shutter steel to provide access holes for the shut-off rods and other equipment. Location of these holes was accurate to ¼ in. in level, and at no point did the roof drop below the horizontal.

The chimney was originally designed as a tapered reinforced-concrete stack without filters. Research then in progress showed the desirability of filters and the chimney was modified, the filters being incorporated in the top of a parallel chimney, 44 ft. in diameter by 404 ft. high. Accommodation for the filters is provided in a steelwork cage weighing over 3,000 tons; the form of this cage, which changes the internal shape of the chimney from circular to square and back to circular, is shown in the illustration on page 315. The filter units are removed by remote control and lowered, in lead coffins, to the bottom of the stack by a 7½-ton hoist.

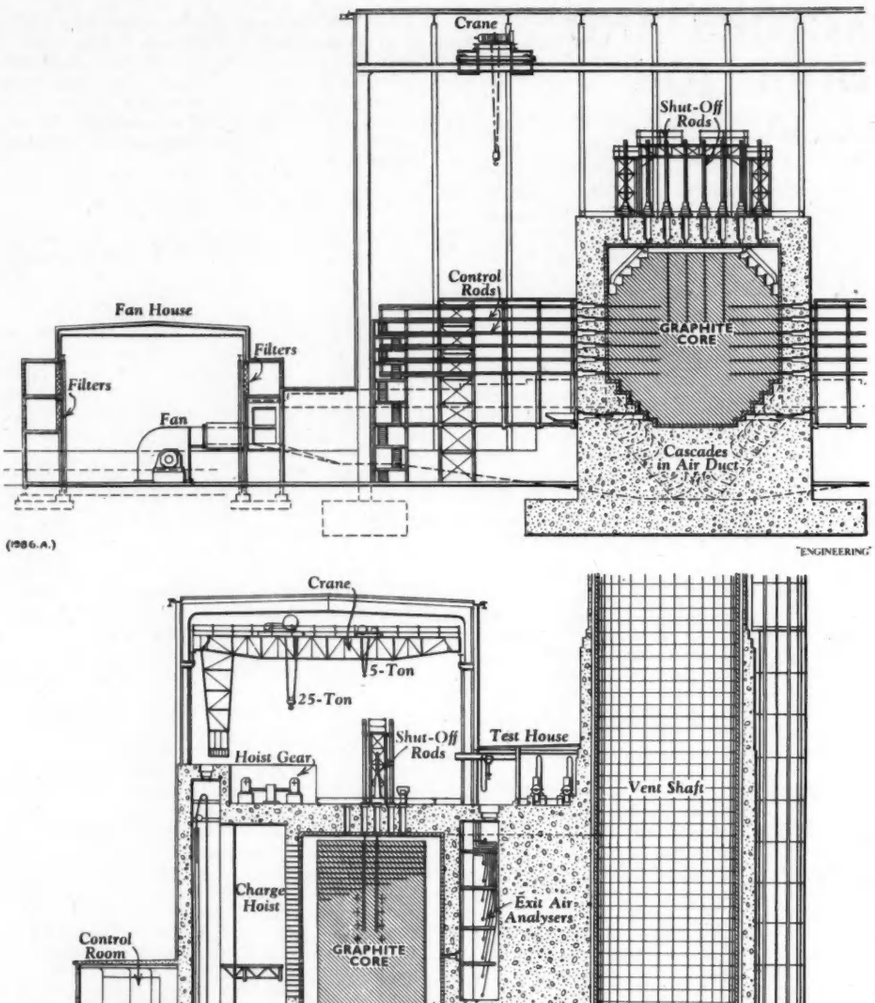
The graphite moderator was designed to resist an air load of about 300 tons tending to blow the graphite towards the chimney; this load is carried by transverse joists and a vertical knife-edge girder up the centre of the discharge face. To keep the graphite structure in compression sideways, coil springs have been installed between the sides of the graphite and the steel thermal shield. Due to the different coefficients of expansion of the several materials involved, some ingenuity was required to determine the fixing points within the structure. Stacking the graphite was begun while building work was still in progress and many precautions had to be taken

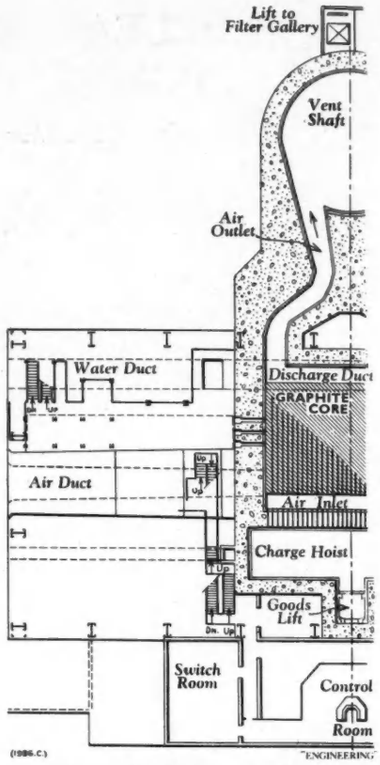


The permanent shuttering for the reinforced - concrete "biological shield" for BEPO. Loading and controlling the pile are effected by inserting rods through holes in the shield into channels left between the graphite blocks of the core. The accurate location of the holes was obtained by welding tubes to the permanent steel shuttering.

* James Clayton Lecture. Delivered at the Institution of Mechanical Engineers on Friday, February 6. Abridged.

† Deputy Controller of Atomic Energy (Production), Risley, Lancashire.





Cross-sections and half-plan of a Windscale pile. The mass of the graphite moderator lies within the confines of a thick reinforced-concrete " biological shield." Cooling air is supplied by centrifugal blowers driven by 11-kV induction motors developing 3,000 h.p. The whole structure – graphite core, shield, ancilliary buildings and chimney stack – weighs about 58,000 tons and is carried on a concrete raft having an area of 21,000 sq. ft.

to prevent the contamination of the graphite by dust or dirt.

The Windscale piles are essentially simple. The problems facing the designers were frightening both in their complexity and in their high content of the unknown. Reducing such problems to the terms of well-understood engineering structures so simple that even the unknown ceased to give cause for alarm, has been the main skill of pile design.

LIMITATIONS BY TEMPERATURE

Unfortunately, there is no way of converting nuclear energy into power without going through a heat cycle. In designing a reactor for the production of industrial power, therefore, the heat should be released at the highest possible temperature. In respect of the nuclear-physical phenomena there is no reason why the fission process should not be operated at an extremely high temperature, but tight limits are imposed by engineering and metallurgical considerations. Nevertheless, it is essential that the first power-generating reactors shall be successful, even if their successful operation is secured at modest temperatures only. Though the dimensions of the core are determined primarily by criteria of nuclear physics, the permitted rate of heat release is solely a question of engineering design of the cooling system.

Natural uranium contains only a small proportion of fissile element U235, and when used in a reactor most neutrons from a U235 fission are absorbed by U238 atoms so that a chain reaction becomes impossible. This is overcome in the " thermal reactor " by arranging the uranium within a moderator which slows the neutrons to so-called " thermal velocities," at which speed they are less likely to be absorbed by atoms of U238 and are more likely to give rise to fission of more U235 ; in these circumstances, a chain reaction can be maintained. Because of the need of a moderator, and the relatively large quantities of natural uranium required for a critical assembly, natural uranium reactors tend to be large in size.

However, by using enriched uranium (containing a higher percentage of fissionable U235) makes it possible to reduce the total uranium charge, and hence the overall size of the reacting core may be reduced. If enrichment could be carried far enough reactors could be constructed in which no moderator was required and where the fission process was conducted by high-energy neutrons only. Such " fast reactors " would be refuelled either by further supplies of enriched uranium or by artificial blends of plutonium and U238. The cost of enrichment is high, which demands that the maximum quantity of heat shall be removed from a given quantity of fuel; that is, a high specific rating of the fuel must be attained. A sequence of reactors can in fact be visualised, forming an ascending scale of enrichment and specific thermal rating and a descending scale of core size, that is, a smaller moderator and a more compact shield.

In a graphite-moderated gas-cooled thermal reactor of natural uranium, the heat rating is low, say, 1 megawatt per ton, and it is the heat transfer from the surface of the fuel elements to the gas stream that determines final power rating. Heat transfer rates cannot be increased merely by increasing the gas velocity because the cost of pumping then becomes prohibitive. Furthermore, the rates may not be increased by extending the transfer surfaces since (the canning material being an absorber) the charge would then have to be increased. The only independent variable remaining is the surface temperature of the fuel elements, and present metallurgical practice limits this temperature to 400 deg. C.

To reduce the cost of operation, the periods of irradiation must be extended; that is, the periods between the chemical processing of the fuel to remove fission products must be increased. But the design of fuel elements with long irradiation periods is difficult, since growth and distortion of the uranium occurs, and the containers must accommodate these changes without bursting or leakage, and still be capable of being safely handled.

Consider next a reactor having a heat output somewhat higher than 1 MW per ton of fuel in the core; for instance, natural uranium with heavy water as both moderator and coolant, or a slighly enriched uranium using ordinary light water. So much heat will cause the temperature of the fuel to rise unless thinner elements are used. Pressurised water as the coolant would enable the necessary rates of heat transfer to be attained, but thermal stresses might be generated in the material of the containers.

The use of " intermediate " or " fast " reactors without any moderator will give rise to still higher heat ratings. The uranium will certainly be plastic and may be near molten near its centre;

gaseous fission may produce large pressures within the can and large thermal stresses will be generated in materials that are well above the elastic range.

Whatever the type of reactor, the criterion of satisfactory design is compatibility of the uranium (or other fuel), canning material, coolant, and the moderator, under the appropriate conditions of temperature or irradiation. That is to say, the limiting factor in reactor design is the performance of the fuel element.

LIMITATION OF HAZARD

A nuclear reactor presents a hazard because of the possible accumulation of highly active fission products. Graphite- or heavy-water-moderated piles using light water as coolant are inherently dangerous since any loss of coolant from the core would increase the reactivity of the pile. On the other hand, a graphite-moderated pile with air, carbon dioxide or helium cooling, is safe because loss of coolant does not result in the numbers of neutrons being available to cause further fissions. Similarly, light- or heavy-water reactors, using the same substance for both moderator and coolant, can be designed so that no sudden increase in reactivity can occur. For highly-rated thermal reactors, molten metals will be used as coolants; failure of the coolant would then bring about disintegration of the core and vaporisation of the liquid metal. The result of such an accident can be contained by housing the reactor in a vessel which will stand the calculable pressures to arise.

FUTURE FORMS OF REACTORS

At least four alternative types of nuclear reactor exist for power generation and the features of each can be accurately described as follow. The natural development from BEPO and the Windscale pile is a graphite-moderated gas cooled natural uranium reactor (which is an inherently safe arrangement) and two plants of this general type are now being constructed in Cumberland to deliver electric power into the B.E.A. grid. Such a reactor requires an active core about 30 ft. in diameter contained within a pressure vessel of 40 ft. diameter. The maximum surface temperature of the fuel is about 400 deg. C. and the gas coolant circulates at about 100 lb. per square inch. The heat rating is modest – 1 to 2 MW per ton of uranium – but involves a high investment in the uranium.

The heavy-water-moderated natural-uranium reactor is most desirable from the physicist's approach, heavy-water being the best moderator available. The difficulty is that, though the reactor would be smaller (involving lighter foundations) than the first alternative, a plant would have to be developed to produce the quantity of heavy water required. Nevertheless such reactors are feasible, producing heat ratings within the range of 5 to 10 MW per ton of uranium with a cooling system operating at a pressure of, say, 500 lb. per square inch.

The light-water-moderated reactor using enriched uranium would save the cost of the heavy water, but at the price of paying for the enriched uranium from a diffusion plant. The coolant as well as the moderator would be light water to preserve the inherent safety of the plant, and to meet the requirements of heat transfer the coolant would have to be circulated at about 1,000 lb. per square inch. To an engineer the light-water reactor is particularly attractive because of its simplicity and avoidance of extravagant materials of construction. Though less economical in operation than the heavy-water reactor (because of the use of enriched fuel) such a reactor may soon be very important.

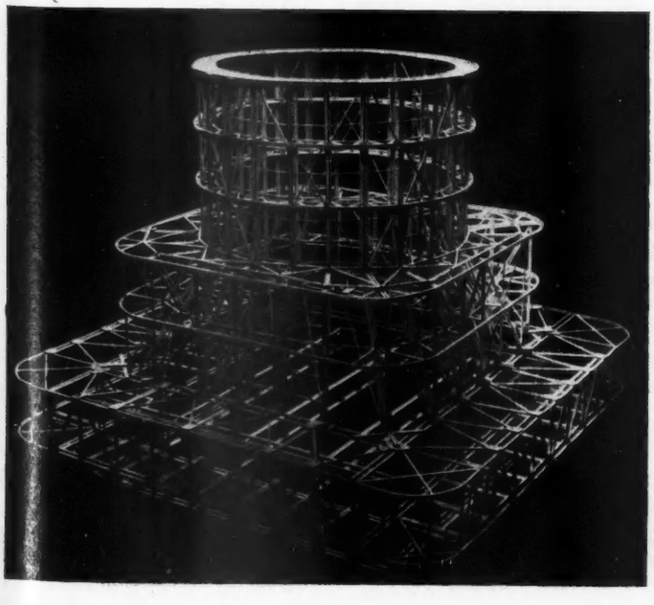
The fourth alternative is the reactor using highly enriched fuel; such a reactor would have a core only 2 ft. in diameter by 2 ft. in length (no moderator being required) and would have a heat rating approaching 100 MW. The heat flux of such an arrangement would be of the order of 3×10^6 B.Th.U. per hour per square foot, so liquid-metal coolants would be desirable. The difficulties are the large temperature gradients and thermal stresses, and the maintenance of reasonably uniform temperature conditions around the surface of the elements.

LARGE-SCALE DEVELOPMENTS

The estimated cost of electricity from a prototype thermal reactor to-day is about 1*d.* per unit or 50 per cent. higher than the average cost from coal-fired power stations. Given experience of construction and operation, the cost of power should be brought down to 0·8*d.* per unit. It would not be surprising if it became fully competitive within 10 years.

The proper application of nuclear energy is to generate electrical power on a large scale and the development might proceed in two stages. Stage (1) would involve building a large number of thermal reactors to make up the existing annual coal deficiency of about 20 million tons. A by-product of plutonium would be produced for use in the second stage.

Stage (2) would involve the use of nuclear reactors employing highly enriched fuel, in particular, the plutonium from the first stage. Whether these reactors would be "fast" or "intermediate" or a type still to be devised cannot be predicted with safety as yet. It would, however, be an objective of this second stage to breed fissile material on a commercial scale.



A model of the upper structural steelwork of the chimney. This steel cage is used to change the circular form of the chimney to square (to receive the filters) and then back to circular. It is located at the top of the 400-ft. high stack.

DUAL-CURRENT RECTIFIER FOR WELDING

Infinitely-Variable Output

A valve rectifier which has been designed to give an alternating-current output of 40 to 240 amperes or a direct-current output of 10 to 80 amperes, has recently been introduced by Philips Electrical, Limited, Shaftesbury-avenue, London, W.C.2. It is intended as a source of power for welding light alloys, non-ferrous metals and light-gauge sheets. Carbon-arc welding can also be carried out and, owing to the wide alternating-current range, it is claimed that it can be used both for fabrication and for repair and maintenance.

When direct current is required the output from the transformer is fed to two rectifier valves, which are protected from premature loading by a time-delay valve and from excessive current input by a micro-switch which is operated directly from a shunt mechanism. The valve output is free from flicker and, since there is no mechanical inertia and only small electrical inertia, response is rapid and the arc recovery time is barely 0·002 sec.

Both the direct-current and alternating-current outputs are infinitely variable and are indicated on a calibrated scale. Selection of the type of current to be used is effected by a change-over switch.

★ ★ ★

CAPACITOR CONTROL RELAY

Power-Factor Improvement

A capacitor control relay made by Ferranti, Limited, Moston, Manchester 10, is now in full production. The instrument is designed for the automatic switching of capacitors employed for power-factor improvement, where each circuit has its own capacitor.

Essentially, the instrument is an induction-disc wattmeter, with the windings arranged to be responsive to the reactive component of the load. The disc is copper and is spring controlled. A contact arm attached to it is central when the power factor is unity; when the power factor becomes less than unity the disc rotates to the right or left as the current lags or leads. Contacts on either side can be adjusted on a calibrated scale so that the circuit is closed at values ranging from 4 to 16 per cent. of the total reactive volt-amperes corresponding to the rated primary current of the current transformer and the supply voltage. By use of a plug board these settings can be multiplied by 1, 2 or 5.

The disc contacts operate an auxiliary relay which, in turn, controls the capacitor contactor. The supply for the auxiliary relay coil is at 100 volts, being transformed and rectified from the main circuit. The instrument imposes a load of 1·5 VA on the current transformer and is fitted with a selector switch so that the capacitors can be manually controlled if desired.

★ ★ ★

PORTABLE ELECTRIC LAMPS

For Use in Dangerous Atmospheres

Oldham and Son, Limited, Denton, Manchester, have introduced a new series of accumulator-operated portable lamps. One of the new series is particularly designed for use in oil refineries, gasworks and similar establishments, and has been approved for use in dangerous atmospheres by both the Ministry of Fuel and Power and the Ministry of Transport. The body is of hard-moulded rubber, and the light of 46 lumens lasts for 8 hours with one charging.

The series also includes a shunter's lamp which is equipped with red and green shutters for signalling. The bulb has two filaments, so that the failure of the first does not make the lamp ineffective. There are also 2-cell and 3-cell hand torches and an improved cap lamp for miners.

ASSOCIATED DYNAMO AND MOTOR MANUFACTURERS

The annual dinner of the Associated Dynamo and Motor Manufacturers was held at the Trocadero Restaurant, London, on February 16, Mr. F. H. Schroeder being in the chair. The toast of "The Associated Dynamo and Motor Manufacturers" was proposed by Lord Sempill, who said our country had always produced, and would continue to produce, inventive genius. It was unfortunate therefore that there was a tendency for the services of these people to be lost owing to lack of encouragement. The expanding electrical industry was endeavouring to discover every kind of device which would increase efficiency, but the same enterprise was not always shown elsewhere. Men should therefore be encouraged to transfer from these industries to others where their skill would be better utilised. Moreover, the attitude towards labour-saving machinery must be changed.

In reply, Mr. J. S. Ramsden said that when the Association was formed 24 years ago, conditions were very different from what they were to-day and were, in particular, discouraging to the younger men.

Proposing the toast of "The Guests," the chairman said the year had seen a change from a sellers' to a buyers' market in its fiercest form. They were still hampered by export restrictions, unavailability of currency and the growth of indigenous manufactures. They were, however, determined to overcome these difficulties and some encouragement in the way of a reduction of taxation on profits would be welcome.

* * *

36-MVA HIGH-SPEED ALTERNATORS FOR SPAIN

The first of two large high-speed salient-pole alternators has recently been completed at the Rugby Works of British Thomson-Houston Company, Limited, for the Artias hydro-electric power station in Spain. It will be driven at 600 r.p.m. by an overhung Pelton wheel at each end and will have an output of 36 MVA.

The runaway speed of these machines is 1,100 r.p.m. and on test they have given an efficiency of 98·2 per cent., which satisfactorily exceeded the guaranteed figure. A high fly-wheel effect is also guaranteed.

The Artias station is situated in the Pyrenees at a height of more than 3,700 ft. above sea level, so transport is difficult. The rotors have therefore been provided with stub shafts which are bolted to each end of a prestressed hollow forging. This forging forms the centre hub to which the poles are secured by four dovetails. All the poles and both stub shafts will be removed before the machines are shipped, but even then the centre hub will weigh 40 tons.

* * *

NEW FLUORESCENT LAMP

Blending with Tungsten-Filament Lamps

The Electrical Lamp Manufacturers Association, 25, Bedford-square, London, W.C.1, have announced the introduction of a new range of fluorescent lamps to be known as "Deluxe Warm White." These lamps will have a higher efficiency than the existing "Warm White" lamps and a colour rendering similar to that of a tungsten-filament lamp, with which they will therefore blend satisfactorily. Experiments show that the new lamps should be particularly useful for lighting homes, restaurants, offices and shops.

The efficiency of the "Warm White" lamp has also been improved – by 15 per cent. in the 80-watt size – and its colour will also be better.

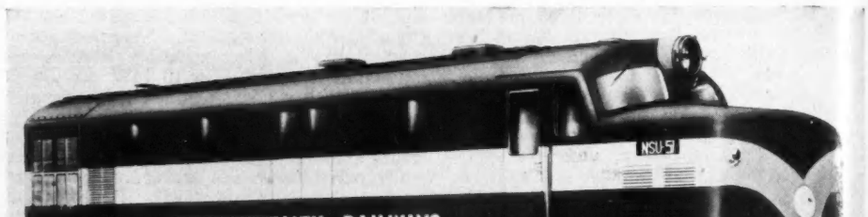


Fig. 1 One of the 955-h.p. Diesel-electric locomotives for the Commonwealth Railways of Australia. These locomotives have been specially designed for operation in sandy areas.

955-H.P. DIESEL-ELECTRIC LOCOMOTIVES FOR AUSTRALIA

PRESSURISED ENGINE-ROOM AND BOGIES FOR TWO GAUGES

The motive power of the 3 ft. 6 in. gauge Central and Northern lines in Australia is being increased by 14 general purpose Diesel-electric locomotives. An interesting feature of the engines, the main contractors for which are the Birmingham Carriage and Wagon Company, Limited, Smethwick, is that four spare 4 ft. 8½ in. gauge bogies have been provided so that two of the units can be used on the new Port Augusta – Marree line in South Australia. Owing to the lightness of the rails the speed is limited to 50 m.p.... and the maximum axle load to 10·3 tons. This has, however, been attained without using light alloys for the structural members. The high temperatures, which may reach a maximum of 118 deg. F. on the Central line, combined with a relative humidity of 30 per cent. and hot sand-laden winds, have made it necessary to "pressurise" the engine room.

The Australian Central and Northern lines are separate systems. The first runs 771 miles northward from Port Augusta to Alice Springs and has a ruling gradient of 1 in 60 with uncomplicated 460 ft. curves. The latter runs south from Darwin to Birdum, a distance of 316 miles and the gradients are easier.

The new locomotives, one of which is illustrated in Fig. 1, are of the A-1-A – A-1-A type. They are 41 ft. 10 in. long over the headstocks, the overall width being 9 ft. 4 in. and the overall height 12 ft. 9 in. The maximum weight in working order is 62½ tons and the maximum tractive effort 26,800 lb. The specified hauling capacity was 202 tons up a 1 in 60 uncompensated gradient, but the designed rating is 270 tons.

MECHANICAL DESIGN

The mechanical portion, for which the Birmingham Carriage and Wagon Company are responsible, consists of a welded superstructure of steel plate and pressed sections, which is riveted to the welded underframe. The end buffing load of 100 tons and the weight of the equipment are entirely sustained by the under frame in which there are no standard rolled sections. The drag and buffing shocks are absorbed by the main longitudinals, which are of box section and are used as ducts for distributing the ventilating air to the traction motors. The main transoms have been specially designed to accommodate the low position of the centre pivots, and outriggers have been arranged so that there is a clear run below floor level for cables on one side and for air piping on the other. Easy access to these services is obtainable by lifting chequered aluminium plates. From the cab bulkhead forward, however, the flooring is of steel plate, which forms part of the anti-collision nose housing the brake reservoirs and batteries.

Both the bogie frame and bolster are fully stress-relieved welded steel structures. The main members of the bogie frame, which is illustrated in Fig. 3, are of box form, while the side members are open boxes to accommodate the equalisers. Although the bogie is of the swing-bolster type, the bolster itself is not sprung, the suspension consisting of nests of springs between the side equalisers and the frame. As a result riding over the light tracks should be easy, especially as shock absorbers have been

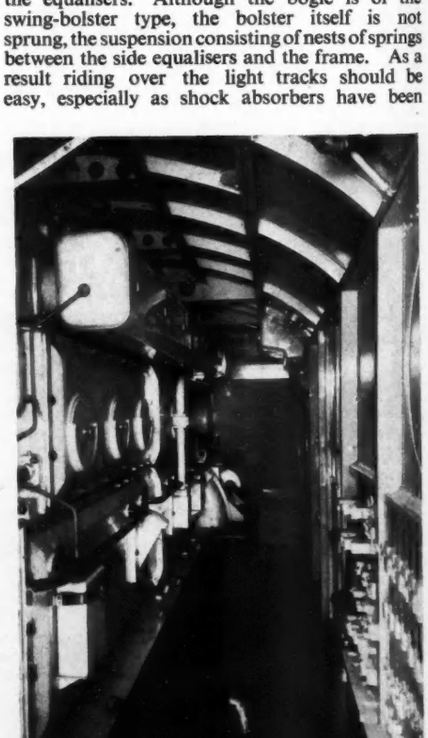


Fig. 2 View inside the engine-room, which is maintained under a slight pressure to prevent the ingress of sand and dust.

fitted to damp out the bounce. The bogie swing links are carried on knife edges and the side swing is stabilised by horizontal pre-loaded rubber springs and limited by stops.

The bogie centre pivots and side bearers are flat and are reinforced with manganese-steel liners. Care has been taken to ensure that the vertical loads and traction and braking stresses are taken centrally and in line on the main frame members. There is an interlock on each side of the underframe to prevent the bogie swinging round in event of derailment or the superstructure becoming detached. The axle boxes are of the Timken roller bearing type with manganese steel thrust faces and liners. The diameter of the driving wheels is 36 in.

The cab extends for the full width of the locomotive and is built up of outer panels of steel and inner panels of aluminium with interposed Isoflex insulation. The bulkhead between the cab and the engine room is of the same double construction, but the insulation is of asbestos.

POWER UNIT

Operating power is provided by a pressure-charged vertical four-stroke engine with six 11 in. by 14·2 in. cylinders. This engine, which was supplied by Sulzer Brothers (London), Limited, 31 Bedford-square, London, W.C.1, has a one-hour rating of 955 h.p. at 750 r.p.m., and a continuous rating of 850 h.p. at 700 r.p.m., both under Australian conditions. Its principal features are a mild-steel crankcase with cast-steel transvervals, both of which are welded; the crankcase and under bed of the set being an integral structure.

An inlet and an exhaust valve are housed in each cylinder head and the inlet and exhaust passages are aerodynamically shaped. The pistons are of forged aluminium alloy and drive fully-machined and polished I-section chrome-nickel steel rods. The steel crankshaft is fully annealed and at its forward end is a Sarazin vibration damper, which allows safe operation at any speed. The individual fuel-injection pumps have double helix plungers and, like the inlet and exhaust valves, are operated from a gear-driven camshaft. At the back of the engine on the main generator frame is an exhaust-gas pressure charger which consists of an aluminium-alloy impeller and a turbine rotor built up of individually-milled steel blades.

The engine circulating water and lubricating oil are cooled by two Serck radiators through which air is drawn by an electrically-driven fan and expelled through the roof. The motor driving this fan is connected electrically to the motor driving the traction blower. It is controlled by contactors, so that both motors run at the same speed until the fifth notch on the main controller has been reached.

PRESSURISED ENGINE ROOM

As already mentioned, these locomotives will be required to run in a dusty atmosphere. The commodious engine compartment, which is illustrated in Fig. 2, has therefore been "pressurised." The equipment installed for this purpose comprises two electrically-operated fans which draw air upwards through grilles in the side panels and then force it downwards. The larger particles are thus deposited at floor level. The air is next passed through Visco oil-wetted filters into the engine room under a slight pressure, where it is used for cooling the generator and traction motors and for supplying the compressor. A small portion is also employed for ventilating the cab. It is discharged through outlet traps, which have a snap action against rubber sealing rings, so that they can be instantly closed if the locomotive should run into a sandstorm. They can also be adjusted to regulate the pressure.

ELECTRICAL EQUIPMENT

The engine is connected to a main-auxiliary generator assembly, which was manufactured by Crompton Parkinson, Limited, Aldwych, London, W.C.2. This is a single-bearing machine with a parallel roller bearing at the outer end. This bearing is carried in a removable cartridge, so that the end shield and the magnet frame of the auxiliary generator need not be removed if it has to be replaced. The inner end of the main rotor embodies hand barring gear, so that the whole set can easily be turned over.

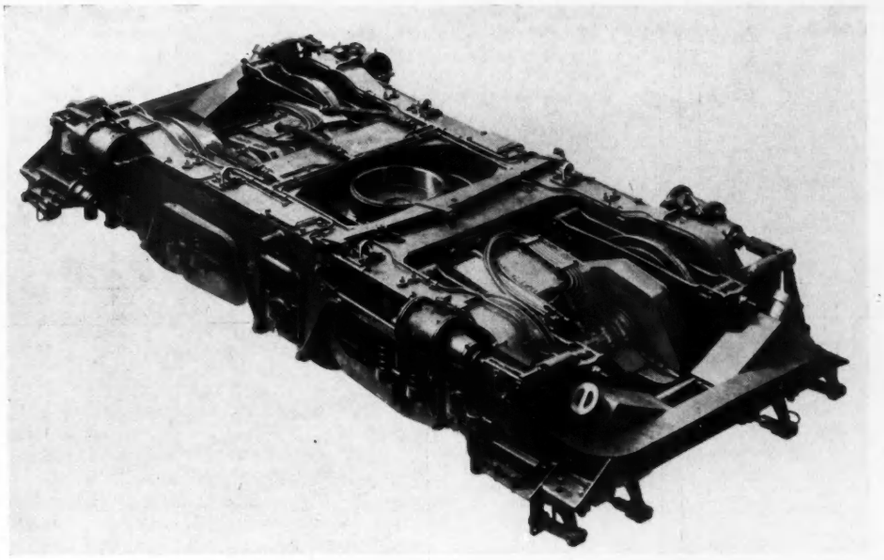


Fig. 3 Two-motor bogie for 3 ft. 6 in. gauge tracks. Bogies for standard-gauge track have also been supplied.

The main generator has a continuous rating of 535 kW at 535 volts and 700 r.p.m. The magnet frame is of cast steel and the armature, as well as that of the auxiliary generator, are combined on a common rotor of bottle form and of the same material, thus providing great stiffness with light weight. Tandem brushes are used and the brush holders are carried on a revolving rocker to facilitate access. The main and auxiliary commutators are secured on separate steel hubs, the bars being of hard-drawn copper insulated with micanite. Both the field and armature coils are fully pressed and bakelised; and the main insulation is carried through the complete length of the armature coils. Shrinkage in service is thus eliminated, while rigidity, freedom from breakdown and close dimensional tolerances are obtained.

The auxiliary generator is rated at 63 kW and 110 volts when running at 500 to 750 r.p.m., the voltage being maintained constant by a carbon pile regulator. It is recessed into the main generator, thus shortening the length of the unit without sacrificing accessibility, and its construction is similar to that of the main generator.

The main generator supplies four traction motors, each of which has a continuous rating of 165 h.p. The coils, armature and commutator of these motors are of similar construction to that of the generator; and the brush gear consists of boxes which are held on a rocker ring. This ring can be rotated in the usual way while the radial distance between the brushes and the commutator can also be adjusted. Forced ventilation is provided by an electrically-driven set in the engine room, consisting of a motor with a Keith Blackman blower on each side. Each blower supplies two motors through ducts in the underframe and horizontal bellows.

Bar suspension is employed, with a pivot between the motor frame and the bar itself, above and below which are springs. The axle suspension bearings are of the plain type and the drive is through single-reduction non-resilient gears.

The control equipment in the cab consists of a power controller (but no separate engine throttle), reversing key and engine start-and-stop levers. There is also a deadman's handle, a combined brake controller for the locomotive and train brakes, an instrument panel and the usual accessories. The 18-notch controller is matched to the engine regulator so that the peak tractive effort at one end of the output curve and a relatively high track speed at the other end can each be obtained on a low controller notch. The higher notches are used when heavy loads are being hauled at high speeds or to give high rates of acceleration. The engine torque and speed are increased on each successive notch. On the first four notches which are used for starting the tractive effort is also increased successively and reaches a maximum on the fifth notch.

As each notch corresponds to a fixed engine torque and speed the generator and motor fields are regulated, so that overloading cannot occur. The full power corresponding to each notch is available over practically the whole speed range. The amount of fuel which can be injected is automatically controlled by the outlet pressure of the charger. Protection against overload due to pressure-charger faults is also provided.

Power is cut off the traction motors and the engine is shut down if the lubricating oil pressure fails, and if there is an excessive rise in water temperature or a loss of water pressure. Power is also cut off the traction motors and the engine is automatically reduced to idling speed, if over-current occurs in one motor, there is an earth fault on either the generator or any motor, a failure of a traction motor blower or a loss of control air pressure.

The four traction motors are permanently connected in parallel, field weakening being introduced in three stages by electromagnetic contactors which operate automatically when the generator excitation reaches a maximum. The main electrical control gear was manufactured by Allen West and Company, Limited, Brighton.

BRAKE SYSTEM

The brake system complies with the Australian Westinghouse standard, the equipment consisting of two blocks on each disc type wheel. There are four 8-in. cylinders on each bogie, from which the clasp rigging is actuated. Side pads are fitted to this rigging to counteract any tendency of the blocks to slip off the wheel rims owing to tread taper. Air is obtained from a two-cylinder reciprocating compressor, which also supplies the sanders and the electro-pneumatic control gear. In the case of the two locomotives which have been allocated to Northern Australia, one cylinder of the compressor will act as an exhauster. A Sulzer anti-wheel-slip brake is also fitted which comes into action automatically when the sanders are used for starting and assists operation when the adhesion is poor.

Fig. 1 Made principally from scrap, this stretch forming tool – shown here in the centre, with a side member removed to reveal the form block – enables sections to be shaped to curvatures in two dimensions.

FORMING CURVED SECTIONS BY STRETCHING

A stretch forming tool which enables members of widely differing length and cross-section to be formed to a variety of shapes, involving curvetures in two mutually perpendicular planes, has been developed by Blackburn and General Aircraft, Limited, Brough, East Yorkshire. The tool, which is used with an ordinary stretching mechanism, may be easily modified according to the section of the workpiece and the final contour desired. It is therefore suitable for prototype and one-off work. Non-uniform bends and bevels can be formed and varying sections accommodated. Constructed principally from odd lengths of steel channel section, the tool can be built up to any required height or length.

In the stretching process, the member to be treated is placed in an appropriately shaped box-former, if necessary with the aid of hydraulic jacks or other mechanical means. Its ends are then inserted in the jaws of a stretching machine, which sets the member to the desired curvature by applying a tension to it. To provide a box-former of adaptable shape and dimensions is the purpose of the tool here described.

In Fig. 2 are shown the plan and elevations of a typical tool, the essential parts of which are two side members, *a* and *b*, and a base-plate *c*. The side members are steel channel sections, and one (*a*) is made fast to the base and the other (*b*) is adjustably mounted so that it can be held parallel or at a slight inclination to the fixed side member. Inside each side member are rubbing plates *d* and *e*, which can be cut from compressed fibre or a similar material and attached to the channels to provide a sliding surface for the section being formed.

The flexibility of the system applies both to overall length and to the height necessary to accommodate a given curve. Blackburn and General Aircraft, Limited use, for example, five universal tools (7 ft. 6 in., 6 ft. 6 in., 5 ft., 3 ft. 6 in. and 2 ft. 6 in. in length) and it has been found that multiples of these cover almost every requirement.

A form block *g* is sawn from wood to the appropriate shape; and, providing it is carefully cut, this edge needs no further dressing. In addition to forming the workpiece, the block serves to locate the different lengths of universal tool, if more than one is used. Any type of wood, including commercial multi-ply, is suitable for this purpose. The form block is not required to be continuous as the side members provide an adequate guide for the workpiece.

When forming is in one plane only, it is an advantage for the form block to be made equal in width to the section.

To prepare the tool for an operation, the metal strip, section or other workpiece *h*, together with, if necessary, compressed-fibre packing laths, is placed between the side members. The ends are then forced down so that they can be inserted into the jass of the stretching machine, which, when started, stretches the strip to conform to the contour of the form block and sets it permanently to that shape. A typical arrangement of the tool and workpiece, but with one side member removed, is illustrated in Fig. 1.

COMPLEX SECTIONS

When the section of the member to be formed is simple, such as an L-shape with arms at right angles to each other, the member may be supported directly by the form block as shown on the left of Fig. 3, and can be drawn down over the block by means of a hydraulic device. The majority of workpieces, however, are more complex and must be supported by compressed fibre laths *i*. The laths are free to slide during bending, but will ensure that the metal strip maintains its correct shape. This method is illustrated in Fig. 3.

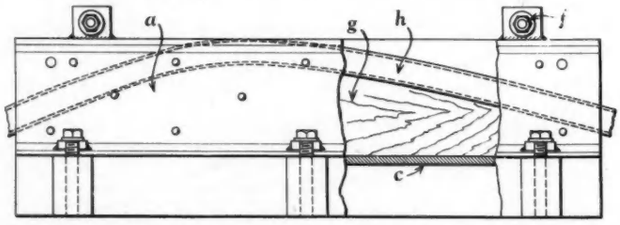
When heavy sections are formed, it is often necessary to fix the ends of the workpiece into the stretching machinery and then to force the form block against the metal strip mechanically, by means of jacks.

If the flange angle changes along the length of the workpiece, the variation can easily be incorporated in the lath when it is straight. In the case of the wooden boxes commonly used, this alteration, which must be made to a curved surface, can only be accomplished with difficulty. Small changes in bevel are therefore often ignored, with a consequent reduction in the quality of the finished article. The universal tool enables this problem to be solved.

CURVES IN TWO DIMENSIONS

The method described can be employed to produce members of double curvature, by forming a curve in one plane and then inserting into the tool a second contour block, for the curve in the plane perpendicular to the first. Sections can also be joggled under load by cutting the impression required, either in the form block, or in the fibre lath, thus eliminating distortion of the contour as a result of the joggle.

The five universal tools, previously mentioned, perform the work of the several hundred stretch forming blocks hitherto employed and thus effect a considerable economy. Even the compressed fibre may be used repeatedly or be re-cut for use with other sections. The tool is simple and easy to operate, requires little storage space, and access to the work through the open top of the tool facilitates manipulation of the metal section.



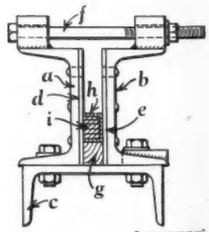


Fig. 2 The workpiece(*h*) – shown in this plan, side and end view of a typical universal stretch forming tool – is placed in the slot between the side members (*a* and *b*), forced down to conform roughly to the form block (*g*) and stretched to set it permanently to that shape.

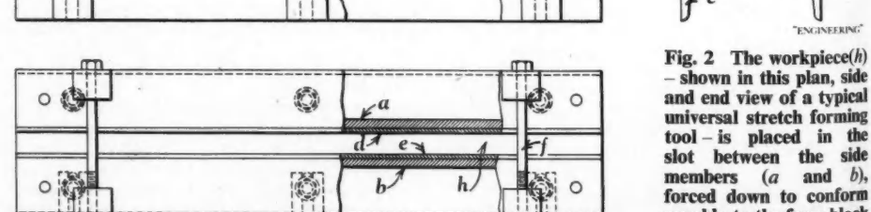


Fig. 3 illustrates the manner in which different sections can be accommodated, using compressed fibre laths in conjunction with a form block to support the more complex sections.

Labour Notes

ENGINEERING AND SHIPBUILDING WAGES

Wage increases of about 5 per cent. for employees in the engineering and shipbuilding industries are recommended in the reports of the courts of inquiry set up by the Minister of Labour and National Service to investigate the wage disputes in these industries. The 39 unions affiliated to the Confederation of Shipbuilding and Engineering Unions had asked for increases of 3*s.* in the pound in the consolidated basic rates of all grades of adult male employees, including men engaged on piecework and at time rates.

A one-day token strike in engineering and shipbuilding establishments took place when the unions' demands were rejected by the Engineering and Allied Employers' National Federation and the Shipbuilding Employers' Federation, respectively. Following the strike, the Confederation recommended the banning of all overtime and piecework throughout the industries, as from January 18 last, but later agreed to suspend the bans until the courts of inquiry had completed their investigations.

The same five men served on both courts. They were Lord Justice Morris (chairman of the two courts), Mr. C. J. Geddes, Sir Harold Gibson Howitt, Mr. H. Lloyd-Williams and Sir Robert Sinclair. The reports of their investigations, one for each industry, were published on February 26 and broadly follow the same lines in each case.

With respect to the claims for a wage increase, the courts state that they hope that the parties concerned in the disputes will resume negotiations, with a view to agreeing to some increase, and suggest that the parties, when they meet, can themselves best arrange the details of the amount and form of the increase. As a pointer, which it is hoped will assist the parties, the courts suggest that the increase agreed to should be something in the region of one-third of the amount claimed, that is, an advance of 5 per cent.

PARTIES NOT BOUND BY COURTS' FINDINGS

Increases of 5 per cent. on wages in the engineering industry would result in skilled men, now earning a minimum of £6 16*s.* 4*d.* a week, receiving an extra 6*s.* 10*d.*; while labourers, now earning a minimum of £5 18*s.* 4*d.* a week, would receive 5*s.* 11*d.* more. Skilled men engaged on piecework, who now receive £7 7*s.* 1*d.* a week, would be paid an additional 7*s.* 4*d.* In the shipbuilding industry, the existing minimum weekly rate of £6 18*s.* 6*d.* for skilled men would be increased by 6*s.* 11*d.*, while the minimum rate for labourers, at present £5 18*s.* 6*d.* a week, would be increased by 5*s.* 11*d.* These rates are based on a week of 44 hours.

Estimates vary as to the number of men likely to receive increases, if granted, but it is generally expected that at least three million employees in the two industries would benefit. On such a basis, the cost might well amount to 45 million pounds a year.

All the parties to the disputes firmly declined to accept the findings of the courts in advance and, consequently, each will be free to decide its own future course of action. The management board of the Engineering and Allied Employers' National Federation hoped to meet early this week to study the report, and the executive council of the Shipbuilding Employers' Federation was due to meet yesterday for a similar purpose.

The executive council of the Confederation met at York last Monday to decide what action should be taken. As was perhaps only to be expected, some disappointment was expressed at the amount of the increase recommended, but it was decided to ask for new talks.

NEED FOR PERMANENT WAGE ORGANISATION

In the case of the engineering claim (*Report on Engineering Industry Dispute*, Cmd. 9084, H.M.S.O., price 1*s.* 6*d.* net), the court refers to the recurring wage negotiations from which the industry suffers. It suggests that repeated wage crises in the industry might be avoided if some form of permanent machinery were set up to keep wages and related matters under review. Such an organisation might do much to dissipate misunderstandings on both sides. Wage negotiations in the past, hard and protracted, had given rise to periods of tension and uneasiness.

When industrial unrest occurred in so important and diverse an industry as that of engineering, the economy of the whole country must be disturbed and the entire community involved.

In these circumstances, the court considers that it might be a most valuable contribution to the solution of these wider problems if an authoritative and impartial body were appointed to consider them. Such an organisation would give advise and guidance as to broad policy and possible action.

BASIS OF NEGOTIATION SHOULD BE WAGE RATES

The court considers that, if arbitration is to continue to be generally acceptable, it must be founded on the principle that wage negotiations must be conducted on the basis of wage rates and not on the basis of earnings, which include overtime. Further, the fact that a wage increase may be inflationary is not, in itself, a valid argument for refusing to recognise the claims of those whose wages have fallen behind the general wage levels of the country.

Average weekly earnings include payments for overtime and bonuses, but some employees, the court states, do not receive these additions to minimum rates. When considering average earnings, it has to be borne in mind that there is no exact knowledge how many of the group of workers are below the average, or to what extent.

It can be no comfort to an employee, who is receiving the minimum rate, to be told that the average earnings of the group which includes him stand at a figure substantially higher than he actually earns. The court considers, however, that overtime is often very welcome.

While a period of general wage stability may be highly desirable, this consideration ought not to weigh so heavily at any particular moment that it rules out of consideration, under all circumstances, any claim which is shown to be just.

To refuse to recognise, because of inflation, the claims of those whose wage rates have fallen materially behind the wage rates of others, is to assume a position which it is difficult to defend.

The court states that it has compared rates in the engineering industry with those applying to a number of other industries and has come to the conclusion that the minimum time rate in the engineering industry is definitely low. Average overall earnings throughout the industry, the court agrees, are relatively high.

PROFITS CONFER WIDESPREAD BENEFITS

On the question of profits, the court states that it has been claimed that a profitable industry can afford to meet wage claims generously. In this connection, the court feels that, in general, profits retained benefit the industry and the shareholder.

Profits benefit the country also, provided that they are not obtained as a result of unreasonably inflating the prices of goods sold, so as to increase the cost of living. Profits benefit workpeople, too, in that they maintain and improve the businesses in which they are employed.

SHIPBUILDING ORDERS

Although two reports were issued, there were many passages which were common to both. In the case of that for the shipbuilding industry (*Report on Shipbuilding Industry Dispute*, Cmd. 9085, H.M.S.O., price 1*s.* 6*d.* net), the court comments that orders at present on hand, subject to possible cancellations, should ensure employment generally for the next three to four years. At the same time, recent cancellations and the falling off in new orders constitute a warning to the industry which it would be " imprudent to ignore."

ARBITRATION IN ALL DISPUTES

Appeals for the settlement of disputes by arbitration in all industries were made by Sir Godfrey Ince, Permanent Secretary to the Ministry of Labour, in a speech at Coventry on February 23. He said that, on a previous occasion, he had questioned whether constitutionalism in industry had gone far enough. There was provision in the constitutional machinery of many industries, agreed to by both employers and workpeople, for finality in respect to arbitration. He had suggested, and he did so again, that that finality should be extended to all negotiating machinery, by way of jointly-agreed provisions, for matters in dispute to be referred to arbitration, when parties failed to settle their difficulties by joint negotiation.

The time had surely arrived when serious consideration should be given to the further development of the country's joint voluntary machinery in this way, in order that strikes and lock-outs should be regarded by employers and workpeople as things of the past.

BRITAIN'S INDUSTRIAL FUTURE NEEDS CAPITAL INVESTMENTS

Comments on this country's future industrial prospects were made by Mr. Alfred Robens, Labour Member of Parliament and a former Minister of Labour, in a speech to his constituents at Blyth, Northumberland, last Sunday. He expressed the view that, given production methods comparable to those in force in the United States, Britain could beat any country with respect to prices.

In support of this view, Mr. Robens said that principals of American firms with factory facilities in Britain had found that production was just as high in this country as in the United States, and that British workpeople produced articles of equal quality at cheaper prices.

If Britain did not produce a greater abundance of high-quality goods at lower prices, with the help of more machines, the country would decline industrially. There was, however, no need for this to happen. Britain possessed the necessary brain power and first-class workpeople, and had occupied a leading industrial position for years. The country could continue to do so, if only more capital investments were made in selected industries.

Mr. Robens said that he would like the Treasury to free sufficient dollar currency to enable an army of salesmen to invade every part of the United States, in the interest of British firms producing suitable export commodities.

NOTICES OF MEETINGS

Aslib

LONDON
"Use and Abuse of Sound Recording," by Miss M. Slocombe and Miss M. Dean-Smith. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Fri., Mar. 12, 6 p.m.

Association of Supervising Electrical Engineers

LONDON
"Electric Motor Application," by A. N. D. Kerr. Central London Branch. St. Ermin's Hotel, Caxton-street, S.W.1. Mon., Mar. 8, 7 p.m.
BIRMINGHAM
"Electroplating," by A. F. Brockington. Chamber of Commerce, 95 New-street, Birmingham. Wed., Mar. 10, 7.15 p.m.
BRADFORD
"Applications of X-Rays: Some Special Diagnostic Examinations," by E. Hudson. Midland Hotel, Bradford. Wed., Mar. 10, 7.30 p.m.
YORK
"Machining Metals." Discussion. City Hall, Lendal, York. Wed., Mar. 10, 7.30 p.m.

British Institution of Radio Engineers

EDINBURGH and GLASGOW
"The Acoustic Design and Measurement of Buildings," by H. C. Watson. Scottish Section. The University, Edinburgh, Fri., Mar. 12, 7 p.m.; and the Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, Thurs., Mar. 11, 7 p.m.
MANCHESTER
"Colour Television," by G. B. Townsend. North-Western Section. College of Technology, Manchester. Thurs., Mar. 11, 7 p.m.

Chemical Engineering Group

LONDON
"Welding of Stainless-Steel Vessels," by J. F. Lancaster. Joint Meeting with Institute of Welding. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Thurs., Mar. 11, 6.30 p.m.

Chemical Society

BIRMINGHAM
"Friction and Lubrication," by Dr. D. Tabor. The University, Birmingham. Fri., Mar. 12, 4.30 p.m.

Incorporated Plant Engineers

LONDON
Annual General Meeting. Royal Society of Arts, John Adam-street, W.C.2. Tues., Mar. 9, 7 p.m.
DUNDEE
Annual General Meeting. Mathers Hotel, Dundee. Mon., Mar. 8, 7.30 p.m.
EDINBURGH
Annual General Meeting. 25 Charlotte-square, Edinburgh. Wed., Mar. 10, 7 p.m.
GLASGOW
Annual General Meeting. Scottish Building Centre, 425 Sauchiehall-street, Glasgow. Tues., Mar. 9, 7 p.m.
NEWCASTLE-UPON-TYNE
Annual General Meeting. North-East Branch. Roadway House, Oxford-street, Newcastle-upon-Tyne. Thurs., Mar. 11, 7 p.m.
NOTTINGHAM
Annual General Meeting. East Midlands Branch. East Midlands Gas Board's Offices, Parliament-street, Nottingham. Wed., Mar. 10, 7 p.m.
SHEFFIELD
Open Discussion on "Maintenance Problems." Grand Hotel, Sheffield. Thurs., Mar. 11, 7.30 p.m.

Institute of British Foundrymen

BRADFORD
"Nodular Cast Iron," by M. M. Hallett. West Riding of Yorkshire Branch. Technical College, Bradford. Sat., Mar. 13, 6.30 p.m.
GLASGOW
"Variety Production in a Jobbing Foundry," by C. B. Scarcliffe. Scottish Branch. Royal Technical College, Glasgow. Sat., Mar. 13, 2.45 p.m.
LINCOLN
"Mechanical Aids to Production," by H. Hadan. Lincolnshire Branch. Lincoln Technical College, Lincoln. Thurs., Mar. 11, 7.15 p.m.
SOUTHAMPTON
"Propeller Manufacture," by J. Langham. Southampton Technical College, St. Mary-street, Southampton. Fri., Mar. 12, 7 p.m.

Institute of Fuel

MANCHESTER
"Design and Operation of Small Water-Tube Boilers," by G. Steward. North-Western Section. Engineers' Club, Manchester. Wed., Mar. 10, 2 p.m. (luncheon, 1 p.m.)
NEWCASTLE-UPON-TYNE
"Ash and Clinker in Practice: Handling and Disposal," by W. G. Marskell and C. W. Pratt. North-Eastern Section. King's College, Newcastle-upon-Tyne. Mon., Mar. 8, 6.30 p.m.

Institute of Marine Engineers

LONDON
"Heat Exchangers for Marine Oil Engines," by H. E. Upton. Tues., Mar. 9, 5.30 p.m.

Institute of Metals

GLASGOW
"Powder Metallurgy," by Dr. D. D. Howat. Scottish Local Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., Mar. 8, 6.30 p.m.

Institute of Petroleum

LONDON
"Surface Failure in Gears," by Dr. A. Cameron. Wed., Mar. 10, 5.30 p.m.

Institute of Road Transport Engineers

BIRMINGHAM
Various short papers. Midlands Centre. Crown Inn, Broad-street, Birmingham. Tues., Mar. 9, 7.30 p.m.
NOTTINGHAM
"Air-Pressure Brakes and Auxiliaries for Road Vehicles," by W. A. Kirk. East Midlands Centre. Mechanics' Institute, Nottingham. Wed., Mar. 10, 7.30 p.m.

Institute of Welding

LONDON
"Welding of Stainless-Steel Vessels," by J. F. Lancaster. South London Branch. Lighting Service Bureau, 2 Savoy-hill, W.C.2. Thurs., Mar. 11, 6.30 p.m.

Institution of British Agricultural Engineers

LONDON
"The Development of Spraying Machines in This Country and Overseas and Methods of Assessing Their Performance," by E. R. Hoare. Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Tues., Mar. 9, 2.15 p.m.

Institution of Civil Engineers

LONDON
"The Design and Construction of a Prestressed-Concrete Framed Transit Shed for the Port of London Authority," by N. N. B. Ordman and I. S. S. Greeves. Structural and Building Division. Tues., Mar. 9, 5.30 p.m.
BIRMINGHAM
Dugald Clerk Lecture on "Highway Construction Plant," by R. R. W. Grigson. Midlands Association. James Watt Memorial Institute, Birmingham. Thurs., Mar. 11, 6 p.m.
HULL
"Engineer Tasks in Future Wars," by Major-General G. N. Tuck. Yorkshire Association. Blue Bell Hotel, Scunthorpe. Wed., Mar. 10, 6.30 p.m.

Institution of Electrical Engineers

LONDON
Discussion on "How Can Electrical Methods Enhance Industrial Productivity?" opened by Sir Henry Clay. Informal Meeting. Mon., Mar. 8, 5.30 p.m.
"A Study of Some of the Properties of Matter Affecting Valve Reliability," by Dr. E. A. O'Donnell Roberts. Radio Section. Wed., Mar. 10, 5.30 p.m.
"An 8-MeV Linear Accelerator for X-Ray Therapy," by C. W. Miller. Thurs., Mar. 11, 5.30 p.m.
BRISTOL
"Telemetering for System Operation," by R. H. Dunn and C. H. Chambers. Western Centre. South Western Electricity Board's Offices, Colston-avenue, Bristol. Mon., Mar. 8, 6 p.m.
NEWCASTLE-UPON-TYNE
"Some Design Features of the Semi-Outdoor Power Station at Ince," by F. H. S. Brown. North-Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Mar. 8, 6.15 p.m.
NOTTINGHAM
"A Study of Some of the Properties of Matter Affecting Valve Reliability," by Dr. E. A. O'Donnell Roberts. Radio Section. Wed., Mar. 10, 5.30 p.m.
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NOTTINGHAM
"Planning Procedure for Rural Development," by A. J. Miller and R. Stephenson; and "The Development of Precision Electric Clocks," by P. Harvey. East Midland Centre, Gas Department's Demonstration Centre, Nottingham. Tues., Mar. 9, 7 p.m.
PORTSMOUTH
"Metadynes and Amplidynes," by E. J. Davies. Southern Centre. Municipal College, Portsmouth. Wed., Mar. 10, 6.30 p.m.

Institution of Engineers-in-Charge

LONDON
"Refractories," by Dr. A. T. Green. St. Bride Institute, Bride-lane, Fleet-street, E.C.4. Wed., Mar. 10, 6.30 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Ships' Lifts," by J. Austwick and S. T. Elvy. Tues., Mar. 9, 6.45 p.m.

Institution of Engineering Inspection

WOLVERHAMPTON
"Engineering Applications of Electro-Deposited Metals," by J. W. Oswald. Compton Grange, Compton-road, Wolverhampton. Wed., Mar. 10, 7.30 p.m.

Institution of Mechanical Engineers

LONDON
"Automobiles on Alpine Passes," by Max Troesch. Automobile Division. Tues., Mar. 9, 5.30 p.m.
"The Productivity Report on Design for Production." Discussion. Industrial Administration and Production Engineering Group. Fri., Mar. 12, 5.30 p.m.
MANCHESTER
Repetition of the Presidential Address, by A. Roebuck. North-Western Branch. Engineers' Club, Manchester. Thurs., Mar. 11, 6.45 p.m.

Institution of Production Engineers

LONDON
"Building of Large Turbo-Alternators," by J. R. Cotterill. Royal Empire Society, Northumberland-avenue, W.C.2. Thurs., Mar. 11, 7 p.m.
Annual General Meeting and Film Evening. London Graduate Section. Wed., Mar. 10, 7.15 p.m.
BLACKBURN
"Thoughts on Works Study Approach to Productivity," by E. H. Shaw. Preston Section. Crown Hotel, Blackburn. Wed., Mar. 10, 7.15 p.m.
BRISTOL
Annual General Meeting. "Spark Machining," by G. Fefer. Western Section. Grand Hotel, Bristol. Wed., Mar. 10, 7 p.m.
IPSWICH
Annual General Meeting and Symposium on "Machine Tools." Eastern Counties Section. Diocesan Hall, Tower-street, Ipswich. Fri., Mar. 12, 6.30 p.m.
LEEDS
Annual General Meeting. "Education and the Production Engineer," by R. Shilton. Yorkshire Section. Hotel Metropole, Leeds. Mon., Mar. 8, 7 p.m.
LEICESTER
"Standard Costs and Budgetary Control as an Aid to Management," by H. Senior. Bell Hotel, Leicester. Thurs., Mar. 11, 7 p.m.
SHEFFIELD
Annual General Meeting. "Work Measurement," by Professor T. U. Matthew. Grand Hotel, Sheffield. Mon., Mar. 8, 6.30 p.m.
WOLVERHAMPTON
Annual General Meeting. "Fuel and Energy Conservation," by W. L. Boon. Wolverhampton and Staffordshire Technical College, Wolverhampton. Wed., Mar. 10, 6.30 p.m.

Institution of the Rubber Industry

LONDON
"Recollections of Events and Personalities in the Rubber Industry, 1903-1953," by Dr. S. S. Pickles; and "V-Belt Manufacture," by J. J. Hickey. Royal Society of Tropical Medicine and Hygiene, 26 Portland-place, W.1. Tues., Mar. 9, 5.30 p.m.
BIRMINGHAM
Various short papers on scope and work of research associations and the Institution; "Development and Service of Off-the-Road Tyres," by M. A. Wilson. Midland Section, James Watt Memorial Institute, Birmingham. Mon., Mar. 8, 5 p.m.

Institution of Sanitary Engineers

LONDON
"Joints in Water-Retaining Structures," by P. L. Critchell. Caxton Hall, Victoria-street, S.W.1. Thurs., Mar. 11, 6 p.m.

Institution of Structural Engineers

LIVERPOOL
"Uses of Aluminium for Structural Purposes," by D. V. Pike. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Wed., Mar. 10, 6 p.m.

Institution of Works Managers

LONDON
"Productivity and the Trade Unions," by Tom Williamson. Waldorf Hotel, Aldwych, W.C.2. Wed., Mar. 10, 7 p.m.

Junior Institution of Engineers

LONDON
"General Principles of Boiler Water Treatment," by W. F. Gerrard. Townsend House, Greycoat-place, S.W.1. Fri., Mar. 12, 7 p.m.
MANCHESTER
Film Evening. North-Western Section. Engineers' Club, Manchester. Mon., Mar. 8, 7.30 p.m.
SHEFFIELD
"Use of High-Frequency Heating in the Metallurgical Industry," by J. B. Ingall. Livesey Clegg House, Union-street, Sheffield. Mon., Mar. 8, 7.30 p.m.

Liverpool Engineering Society

LIVERPOOL
"Uses of Aluminium for Structural Purposes," by D. V. Pike. Wed., Mar. 10, 6 p.m.

Newcomen Society

LONDON
"Some Metallurgical Processes of the Early Sixteenth Century (1530)," by Dr. F. Sherwood Taylor. Science Museum. South Kensington, S.W.7. Wed., Mar. 10, 5.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"Marine Shafting Alignment," by G. Yellowley and Dr. J. E. Richards. Neville Hall, Newcastle-upon-Tyne. Fri., Mar. 12, 6.15 p.m.

Royal Institution

LONDON
"The Search for Lightness," by Hayne Constant. Fri., Mar. 12, 9 p.m.

Royal Society of Arts

LONDON
"Safety on the Railways," by Lieut.-Col. G. R. S. Wilson. Cantor Lecture III. Mon., Mar. 8, 6 p.m.
"Safety in Ships," by Captain J. P. Thomson. Wed., Mar. 10, 2.30 p.m.

Television Society

LONDON
"Trick Effects in Television Production," by D. R. Campbell. Thurs., Mar. 12, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Aslib, 4 Palace-gate, London, W.8. (WEStern 6321.)
Association of Supervising Electrical Engineers, 54 Station-road, New Barnet, Hertfordshire. (BARnet 9141.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Engineering Group, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1. (SLOane 9851.)
Institution of British Agricultural Engineers, 24 Portland-place, London, W.1. (LANgham 3394.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers-in-Charge, 100 Earlsfield-road, London, S.W.18. (BATtersea 1394.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Engineering Inspection, 28 Victoria-street, London, S.W.1. (ABBey 3794.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 36 Portman-square, London, W.1. (WELbeck 6813.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Institution of Sanitary Engineers, 118 Victoria-street, London, S.W.1. (VICtoria 3017.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Institution of Works Managers, 67-68 Chandos-place, London, W.C.2. (TEMple Bar 8324.)
Junior Institution of Engineers, 39 Victoria-street, London, S.W.1. (ABBey 6968.)
Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool, 2. (Central 3717.)
Newcomen Society, 43 King's-road, London, S.W.3. (SLOane 8883.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne, 1. (Newcastle 20289.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Television Society, 164 Shaftesbury-avenue, London, W.C.2. (TEMple Bar 3330.)